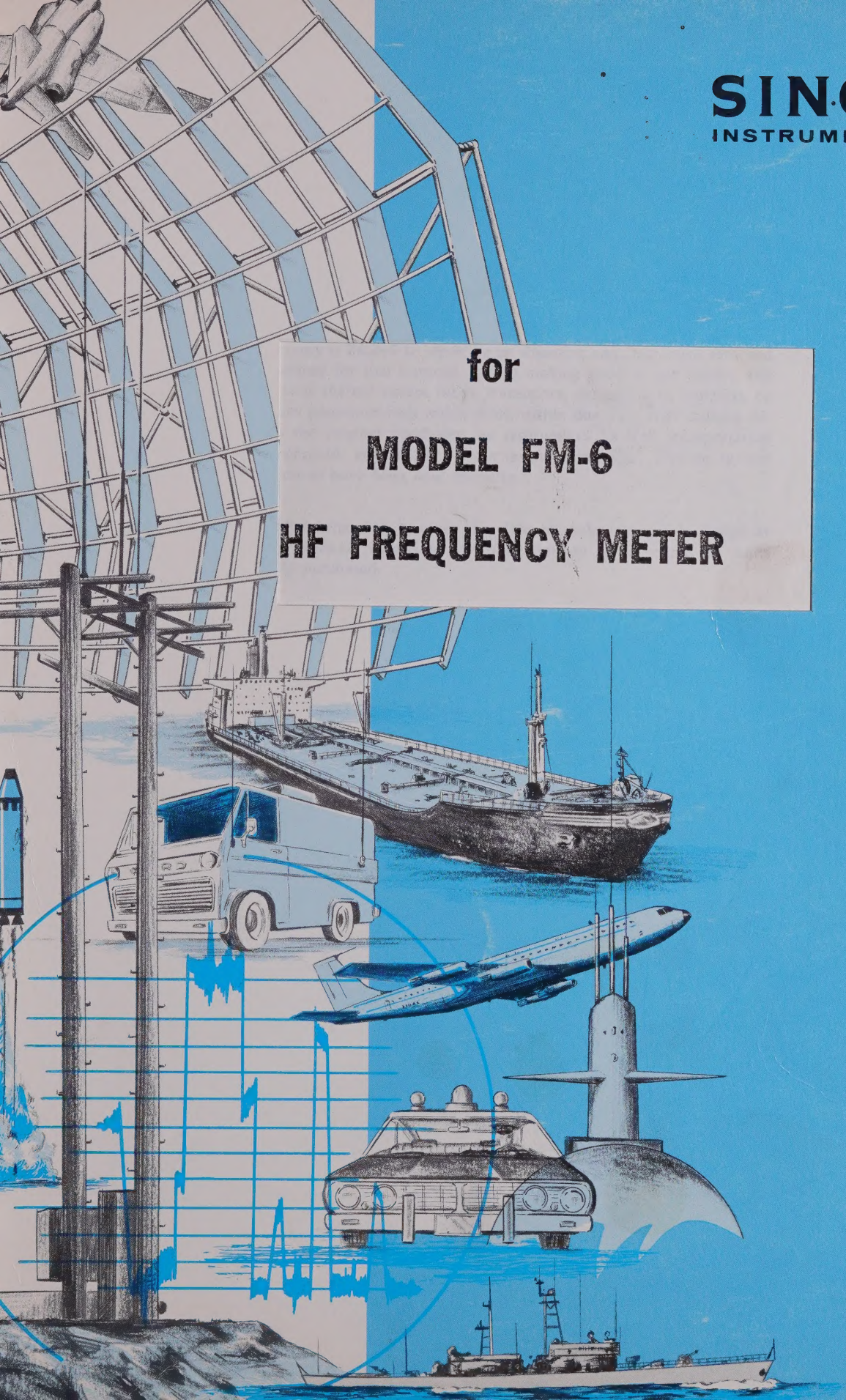
SINGER
INSTRUMENTATION

for

MODEL FM-6

HF FREQUENCY METER



INSTRUCTION BOOK

for

MODEL FM-6

VHF FREQUENCY METER

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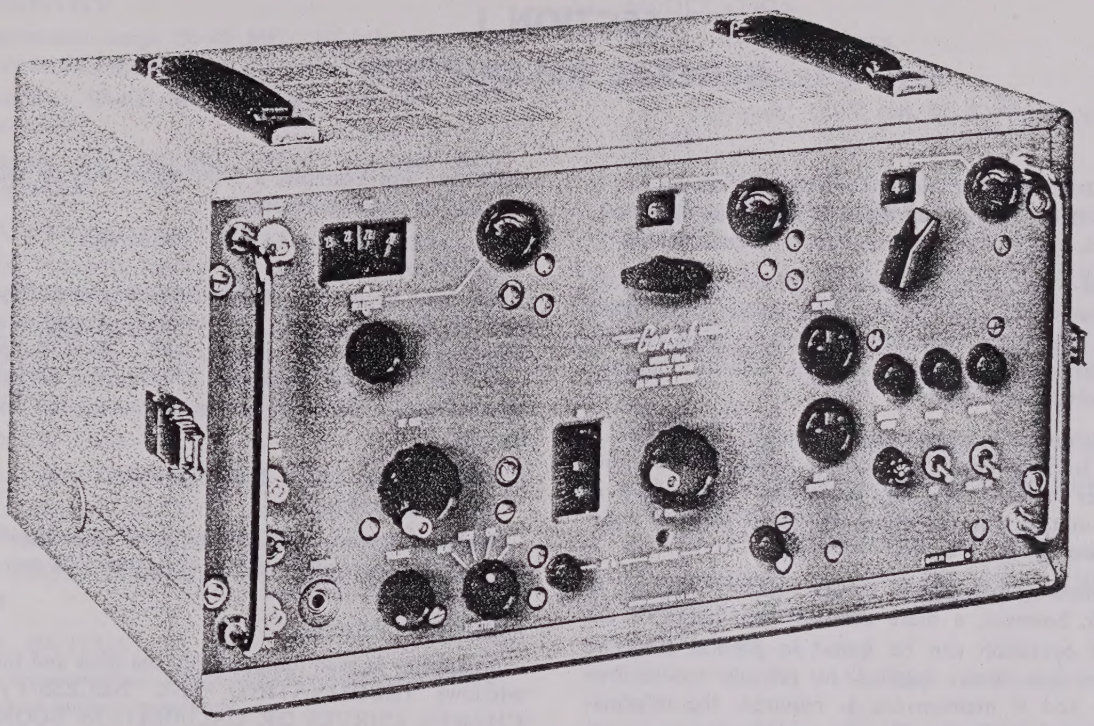


FIG. 1. CASE MODEL FM-6

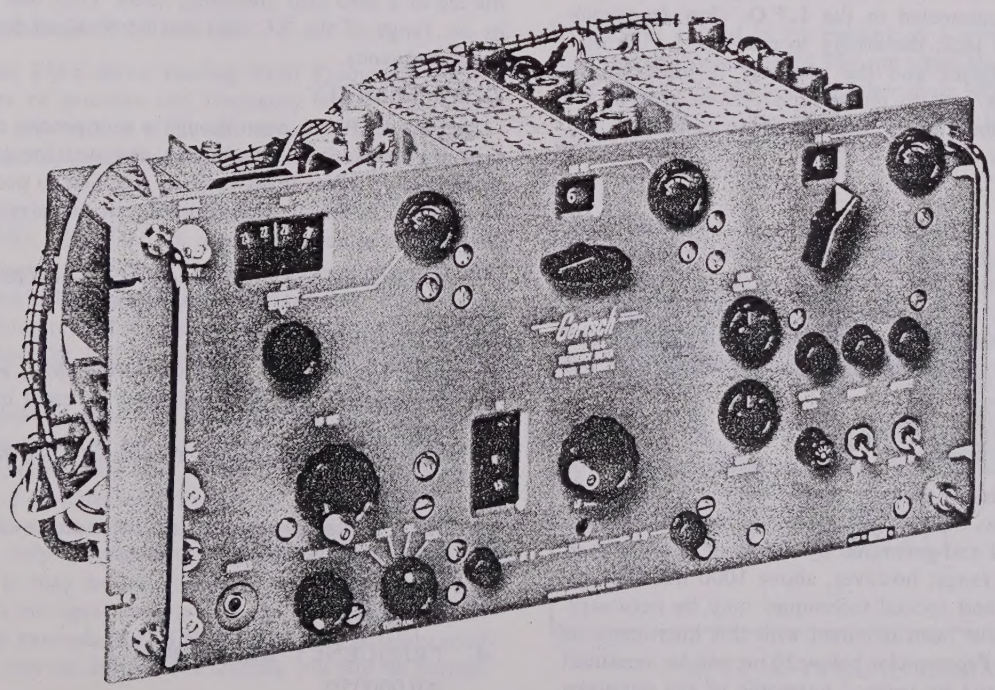


FIG. 2. RACK MODEL FM-6R

SECTION I
GENERAL DESCRIPTION

This instruction book contains information on the FM-6 frequency meter in sufficient detail to permit the operation, adjustment, and maintenance that may be encountered.

The FM-6 has been designed to provide the ultimate in ruggedness and serviceability. The unit is constructed on 6 cast aluminum compartmented chassis units mounted on a heavy aluminum front panel. Chassis units are easily removable for service.

The instrument is supplied in two models. The FM-6 is the basic unit mounted in a cabinet having a removable front cover for dial and knob protection. The FM-6R is the basic unit for rack mounted use and is supplied without the case and front cover.

The following paragraphs briefly describe features of the FM-6; however, a more detailed explanation of the theory of operation can be found in Section III. The instrument has been designed to provide trouble-free operation and if maintenance is required, the information contained in Section IV will provide the user or a competent maintenance facility with sufficient information to perform all maintenance that may be encountered.

1. ACCURACY

The Model FM-6 has a guaranteed accuracy of 0.0001% (one part per million) when used to measure or generate any frequency within its range. By using a 100 kc frequency counter connected to the L.F.O. (low frequency oscillator) output jack, the ability to read the L.F.O. dial is no longer a factor and the accuracy is increased to ±0.00001% (one part in ten million). Even greater accuracy may be obtained by the use of an external 1 mc primary reference standard.

2. STABILITY

The frequency synthesis system used, combined with a wide range automatic frequency lock-in circuit, produces an instrument with a stability of ±0.0001% using the built-in 1 mc crystal standard. After "warm up", the instrument can be set to any frequency within its range and will maintain the generated frequency constantly with the above accuracies.

3. WIDE FREQUENCY RANGE

The instrument has a conservative frequency range of 20-1000 mc. It is a harmonic device with a fundamental range of 20-40 mc. Frequencies up to and beyond 1000 mc may be measured and generated by means of harmonics of the fundamental range; however, above 1000 mc, the amplitude falls off and special techniques may be necessary. Measurements have been obtained with this instrument as high as 2400 mc. Frequencies below 20 mc can be measured (but not generated) by using a harmonic of the unknown frequency. For example, a 5 mc signal may be measured by using its fourth harmonic.

4. CALIBRATION AGAINST PRIMARY STANDARDS

The basic accuracy of the FM-6 is determined by a precise, hermetically sealed, 1 mc crystal mounted in a precision oven maintained accurately to a given temperature in the 85°C. range. Provision is made for adjusting the internal crystal frequency without removing the unit from its case.

5. FCC FREQUENCY MEASURING REQUIREMENTS

Measurement in the VHF and UHF bands to the new FCC tolerance requirement of ±0.0005% is met with a minimum safety factor of 5 to 1.

6. DIRECT READING

Frequency is read directly from the dials and indicating windows (ELIMINATING THE NECESSITY FOR CHARTS, CURVES OR CALIBRATION BOOKS).

7. SIMPLICITY OF OPERATION

In operating, only a rough zero beat with the unknown signal is required with the megacycle dial. The 100 kc and 10 kc dials are decade switched from 0-9 and the proper point is indicated by a maximum reading on indicating meters. Final zero beat is obtained with the KC dial, with the aid of a zero beat indicating meter. Only one zero beat in the range of the KC dial can be obtained for a given input frequency.

8. PORTABILITY

The Model FM-6, even though a very precise measuring instrument, has been specifically designed for portability. A removable metal front cover is supplied to protect dials and knobs. A heavy weatherproof canvas carrying bag is available as an accessory item.

PERFORMANCE CHARACTERISTICS AND SPECIFICATIONS

1. FREQUENCY RANGE

   (A) Measurement 20 MC to 1000 MC. Harmonics of the unknown frequency may be used to measure below 20 MC

   (B) Generation 20 MC to at least 1000 MC

2. ACCURACY

   With ambient temperature between —15°C and +55°C: ±0.0001%

3. STABILITY

   ±0.0001%

4. FREQUENCY RESETABILITY

   ±0.00005%

5. SENSITIVITY

Fundamental range 20-40 MC: 10 MV input for 1 MW audio output (across 600 ohms)

Harmonics 40-400 MC: 100 MV input for 1MW audio output

Harmonics 400-1000 MC: 700 MV input for 1MW audio output

6. READOUT

Direct frequency readout for both measurement and generation — no charts or curves

7. BEAT INDICATOR

Both aural and visual, by means of a panel meter indicator

8. L.F.O. OUTPUT

(for reading counter)

(A) Range: 40-50 KC

(B) Output: 0.5 V rms, 500 ohms source impedance

(C) Output Connector: BNC jack at rear of instrument

9. R. F. OUTPUT

(A) Fundamental Range (20-40 MC): 400 MV, 50 ohms output impedance

(B) Harmonics (40-1000 MC): 2 MV minimum, 50 ohms output impedance

10. MODULATION

Approx. 30% at 1000 cps

11. 1 MC STANDARD OUTPUT

(A) Amplitude: 1.0 V rms, 10 K ohms source impedance

(B) Accuracy: 1 MC ±0.1 cps

(C) Stability: 1 part in 10^7. At any temp between—15°C and −55°C

(D) Output Connector: Front panel BNC jack

12. 1 MC Input Level Required

(When using with external crystal standard) 1.5 Volts rms

13. PORTABILITY

Accessory canvas carrying case available for easy carrying and protection. A removable metal front cover protects meters, knobs, etc.

14. POWER REQUIREMENTS

75 Volt Amperes 115 or 230 VAC 50-60 cps

15. SIZE

Rack 19 x 8¾ x 11 deep

Case: 19¼ x 9¾ x 13¼ deep with front panel cover in place

16. WEIGHT

Approx. 40 lbs.

SECTION II
OPERATION AND ADJUSTMENT

1. FUNCTION OF EQUIPMENT.

The model FM-6 direct reading VHF Frequency Meter will measure or generate any frequency within the range of 20-1000 mc. with a minimum accuracy of 0.0001%. They can also be used below 20 mc. as described in this section.

2. READING THE DIALS.

In the model FM-6 the frequency is read directly on the dials. The H.F.O. dial will read the megacycles, the 100 kc dial the hundreds of kilocycles, the 10kc dial the tens of kilocycles and the L.F.O. dial the remaining digits (0 to 10kc).

It is important that the dial readings correlate each other. For example, if the instrument is set to 23.999 mc, the H.F.O. dial must be very close to 24 mc and the 100kc, 10kc and L.F.O. dials should read 999 respectively. The 1 mc harmonic selector dial in this case should be set to 23. This is the only correct setting to obtain this instrument frequency. It may be possible that the frequency of the H.F.O. does not agree exactly with the dial calibration. In the previous example, the H.F.O. dial might possibly read over 24 mc but the instrument reading will still be correct if attention is paid to the reading as a whole. In this case it obviously cannot be 24.999 mc since the H.F.O. dial is very close to 24 mc and the other dials 999 with the 1 mc harmonic selector dial at 23. Therefore all dial readings must correlate with each other.

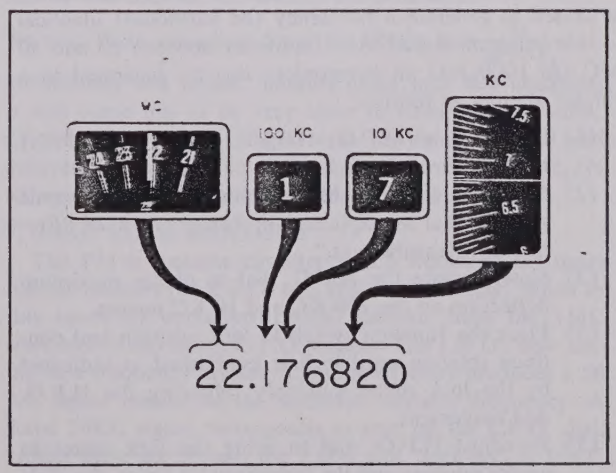


FIG. 3. A TYPICAL READOUT

3. METHOD OF OPERATION

A. HOW TO MEASURE A FREQUENCY.

(1) Connect the signal to be measured to the *input-output* jack.

(2) Place function switch in the beat position.

(3) Rotate the H.F.O. dial to obtain a zero beat with head phones.

(4) Select the proper 1 MC harmonic as follows: The number appearing in the harmonic selector window must be the lower of the two numbers between which the H.F.O. dial pointer lies. For example, if the pointer is between 22 and 23, the number to be placed in the window is 22. Tune for maximum indication on the harmonic selector meter.

(5) Rotate the 100 KC selector switch to get maximum deflection on the meter.

(6) Rotate the 10 KC selector switch to get maximum deflection on the meter.

(7) Move the function switch to *lock* position.

(8) Rotate the H.F.O. dial *slightly* to make certain that lock has been established. This will be indicated by the lock meter following the movement of the H.F.O. dial. The meter is then set to and left at center position.

(9) Rotate the L.F.O. dial to re-establish zero beat. If the measured signal is of sufficient amplitude, the beat indicator meter will enable the beat note to be seen to below one cycle per second.

(10) The frequency being measured (or harmonic) is then read from the dials as in the following example.

MC (HFO)	100 KC	10 KC	KC (LFO)
22	1	7	6820

Which is 22.17682 MC.

B. HOW TO GENERATE A FREQUENCY.

When measuring a frequency with the FM-6, the H.F.O. is caused to generate a frequency (or harmonic) identical to that being measured. Any frequency between 20 and 40 MC (to 1000 MC on harmonics) can be generated in a similar manner as follows:

(1) Set the dials (H.F.O., 100 KC, 10 KC and L.F.O.) to the desired frequency.

(2) Select the correct 1 MC harmonic on the harmonic selector dial as explained in Paragraph 4 of "Frequency Measurement."

(3) Slowly rotate the H.F.O. dial to obtain maximum deflection on the 100 KC and 10 KC meters.

(4) Place the function switch to lock position and continue rotation until lock is established as indicated by the lock meter suddenly following the H.F.O. dial movement.

(5) Re-adjust H.F.O. dial to bring the lock meter to center position and the frequency set up on the dials is now available at the input-output jack.

The direction of H.F.O. dial rotation to obtain lock depends upon the initial dial setting. If lock cannot be obtained by a small rotation in one direction, the direction should be reversed.

C. CALIBRATION.

(1) Set FUNCTION SWITCH to CAL. position.

(2) Set the L.F.O. dial to 10 and adjust the control marked "AT 10" for a zero beat using the beat indicator.

(3) Rotate the L.F.O. dial to 0 and adjust the control marked "AT 0" for a zero beat as in Step 2.

(4) Repeat Steps 2 and 3 until both ends of dial are correct. The order of adjustment as listed above (first 10 and then 0) will be found to give the quickest results.

D. METHODS OF COUPLING.

The method of coupling to the Frequency Meter depends upon the type of source being measured as well as the relative output of the source being measured. In the case of a signal from a transmitter or oscillator, sufficient coupling will be obtained in most cases with the antenna plugged into the Frequency Meter and using the near radiation field from the transmitter. For signal generators and other weak signal devices, direct coupling to the input-output jack via a matched coaxial line is recommended. In this manner signals may be measured throughout the entire frequency range whose voltage magnitude is at least 1000 microvolts. In the case of signals considerably weaker than this the use of an auxiliary receiver to obtain the measurement is recommended. In this case the procedure will be as follows:

(1) Locate the frequency to be measured in the receiver.

(2) Provide suitable coupling between the receiver and the Frequency Meter.

(3) Tune the H.F.O. oscillator until a beat note is heard in the receiver.

(4) Change the receiver tuning slightly and note whether or not the beat note frequency changes. If the beat note frequency changes the response is an image response or a response with a local oscillator harmonic or other type of spurious receiver response. If this is the case, continue tuning the high frequency oscillator until a proper response is obtained, that is, one in which the beat note frequency does not vary for slight receiver tuning changes.

(5) Proceed with frequency measurement as in paragraph 3A steps 1 through 10 using the receiver as the beat detector.

4. ADDITIONAL NOTES ON OPERATION.

(1) When the FM-6 is in the locked condition, the lock-in will hold over the entire range of the L.F.O. if the lock voltage meter is reasonably centered by adjustment of the H.F.O. dial.

(2) Accurate measurements and output frequencies will be obtained when and only when the instrument is in the "lock-in" condition.

(3) For maximum accuracy, always use the aligned double lubber line method of eliminating parallax on the L.F.O. dial.

5. USE AT LOWER FREQUENCIES.

The Frequency Meter may be used for measuring frequencies below 20 mc. The only requirements are that the source being measured have sufficient harmonic output so that harmonics fall within the fundamental, that is 20-40 mc., range of the instrument. This requirement can readily be met by most transmitters and if it cannot be met, harmonics can be generated by means of a diode type distortion device. The method of operation is identical with the method of measuring a frequency within the range of the instrument. However, when the final frequency measurement has been made, the dial readings must be divided by the order of the harmonic being measured. For example, if the transmitter being measured has a fundamental frequency of 7.215 mc. the measurement can be made at the third harmonic, which would be 21.645 mc. When this reading of 21.645 mc. has been obtained, it must be divided by 3 to obtain the transmitter frequency. The same accuracy is maintained as in the normal operating range of the instrument.

6. AUXILIARY OUTPUT.

In addition to the normal output of the Frequency Meter, that is, 20 to over 1000 mc. there also is available the output of the low frequency oscillator (40 to 50 kc) from a BNC connector in the rear of the L.F.O. chassis. This output can be used to drive a counter to obtain a greater accuracy in frequency measurement or generation. The counter reading subtracted from 50 kc is the last four digits of the frequency of the FM-6.

The output of the 1 mc. crystal oscillator is also available on the front panel for use as a secondary standard. The specifications of this output are given in step 11 of the overall specifications on page 5.

7. METHOD OF DETERMINING THE FREQUENCY OF AN ENTIRELY UNKNOWN SOURCE.

A. FREQUENCIES KNOWN TO BE ABOVE 20 MEGACYCLES.

The method to be described requires only that the source be known to be above 20 mc. Procedure is as follows:

(1) Using the standard measuring procedure and starting at 20 mc. with the H.F.O., tune the H.F.O. through the entire range and pick out the first strongest beat note against the unknown signal. Measure this frequency very carefully and call it f_1.

(2) Continue tuning upwards in frequency with the H.F.O. until the next response having the beat note of approximately the same intensity is found. Measure this frequency and call it f_2. If only one response has been found of high signal intensity, then the frequency being measured is in the fundamental range of the instrument, that is 20 to 40 megacycles (or 40 to 60 mc. on second harmonic if beat note falls between 20 and 30 mc.) These two cases may be distinguished by the fact that the beat note changes frequency twice as fast as the tuning of the low frequency oscillator if the response is on second harmonic.

(3) If two responses have been found then it is obvious that the first response occurs at a frequency $nf_1 = x$ where n is some integer representing the harmonic being used and x is the unknown frequency, and similarly, since the Frequency Meter was tuned upwards in frequency to the next harmonic response, this response would occur at $(n - 1)\ f_2 = x$ where $n - 1$ indicates that the next lower harmonic of the Frequency Meter was being used when f_2 was measured. Solving these equations for n we obtain $n = \frac{f_2}{f_2 - f_1}$. Having substituted the actual measurements into this equation, n will come out to be very close to some integral value. Choosing the closest integral value for n the unknown frequency is then this integer times f_1 or $x = Nf$ where N is the closest integral value to the n calculated by the equation above.

B. FREQUENCIES KNOWN TO BE BELOW 20 MEGACYCLES.

(1) Starting at 20 mc., tune the H.F.O. throughout its range and select the first loudest response. Measure this frequency carefully and call it f_1.

(2) Continue tuning upwards in frequency until the next response of approximately the same intensity has been obtained. Measure this and call it f_2. If no second response can be obtained, then the response is a second harmonic response and the frequency of the unknown would be $\frac{f_1}{2}$.

(3) If a second response was obtained, then it is obvious that the first response was obtained at a frequency $nx = f_1$, where n is an integer representing the harmonic of the source that was used in the measurement of f_1 and similarly, the second response would occur at $(n + 1)\ x = f_2$ indicating that the next higher harmonic of the source was used in the second measurement.

Solving these equations for n we obtain $n = \frac{f_1}{f_2 - f_1}$. Substituting the actual measurements into this equation, n will come out to be very close to some integral value. Choosing the closest integral value to the n obtained and substituting into the equation above, we obtain $x = f_1/N$ where N is the integral value obtained above.

7. 10KC LOCK FEATURE

The FM-6 contains circuitry which would, at the users option, convert the L.F.O. to a frequency divider. When in this mode of operation 100KC derived from the 1MC time base is fed to the L.F.O. chassis. The L.F.O., now acting as a frequency divider (dividing by two) produces a 50 KC signal instead of the 40-50KC variable frequency. A fixed 50KC signal corresponds to zero on the L.F.O. dial. Under these conditions, the FM-6 will "lock-up" at 10KC intervals with the frequency stability approaching the internal 1 MC time base.

A two position switch, S401, accessible from the front panel is used to select the mode of operation.

Access to S401 is by means of a ¼ inch hole in the front panel directly below the L.F.O. control knob. The switch shaft is slotted for screwdriver operation.

NOTE: The L.F.O. dial must be set to approximately 2.25 in order to pass a screwdriver through a hole in the L.F.O. dial when switching S401.

Switching to the 10KC lock position will disable the L.F.O. light as an indication of the mode of operation.

SECTION III
THEORY OF OPERATION

1. GENERAL

With reference to the block diagram, it may be seen that the portion outlined by dotted line comprises a simple heterodyne frequency meter. Unknown signals are fed into the BEAT DETECTOR and compared against the fundamental or harmonic output of the HF OSC. and BUFFER. The resultant zero beat is amplified and presented by both aural and visual means. Since the HF OSC. dial is calibrated in 1 MC increments only, to obtain a reading accuracy of 1 part per million, a means of interpolating between the 1 MC points must be provided.

In the FM-6 a stable frequency base is provided by the use of a 1 MC CRYSTAL OSC., the stability of which is better than one part in 10^7. Harmonics of this oscillator are available from the 23rd to the 42nd by means of a tunable harmonic amplifier. Heterodyne action between the H.F.O. and the proper 1 MC harmonic produces an IF frequency always between 2 and 3 MC. For this example the H.F.O. is set to a frequency of 22.176820 MC and the 25th harmonic of the 1 MC oscillator is selected, resulting in a difference frequency of 2.82318 MC.

The first IF amplifier frequency is pre-tuned in 100 KC steps from 2.95 to 2.05 MC, and selected by means of the 100 KC decade switch, positions 0 to 9. In operation the 100 KC switch is rotated for maximum output, as indicated on the 100 KC meter. Since the frequency of interest is 2.82318 MC an IF frequency of 2.85 MC (Position 1) would produce maximum output.

The 1 MC oscillator output is divided by 10 twice so that 100 KC and 10 KC signals are available. As the first IF amplifier was tuned with the 100 KC switch, a harmonic of the 100 KC was selected so that a second IF frequency between 300 and 400 KC would be produced. In this example, the 32nd harmonic of 100 KC (3.2 MC) mixing with the output of the first IF amplifier (2.82318 MC) produces a 2nd IF frequency of .37682 MC. In a similar manner, the second IF amplifier is pre-tuned to 10 frequencies from 305 to 395 KC in 10 KC steps. The 10 KC decade switch is rotated until a maximum output is indicated on the 10 KC meter. Since the frequency of interest is .37682 MC an IF amplifier frequency of .375 MC (Position 7) will result in maximum output.

Again, as this second IF amplifier is tuned a harmonic of the 10 KC is selected so that a third difference frequency between 40 and 50 KC is generated. To produce this 3rd IF frequency of 43.18 KC and 42nd harmonic of 10KC (.42 MC) was mixed with the output of the 2nd IF amplifier.

The output of the 3rd IF amplifier is compared in a phase discriminator with a continuously variable LOW frequency oscillator. Any phase difference becomes an AFC signal to correct the H.F.O. This loop then phase locks the H.F.O. The stability of the system is a function of the stability of the 1 MC oscillator and the L.F.O. Since the L.F.O. may be calibrated against the crystal, the stability then approaches that of the 1 MC crystal oscillator.

Harmonics of the 20-40 MC H.F.O. are used to zero beat against higher frequency, enabling frequency measurement and generation far beyond the fundamental range.

2. DETAILED DESCRIPTION

A. HIGH FREQUENCY OSCILLATOR AND 1 MC HARMONIC AMPLIFIER.

The H.F.O. (V104) is a Hartley E.C.O., continuously variable from 20 mc to 40 mc by capacitor C118.

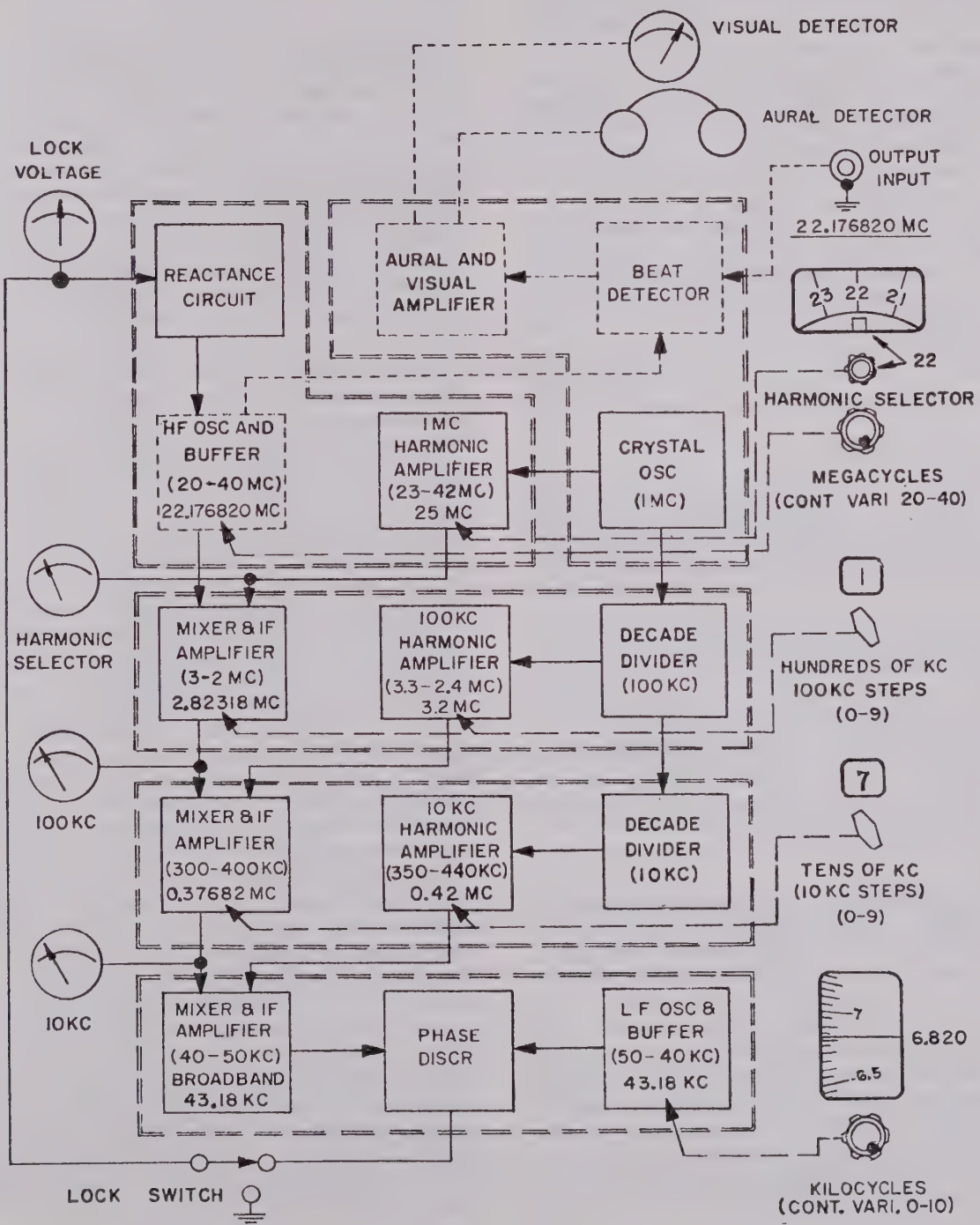
A voltage sensitive silicon capacitor (CRC101), across part of the tank circuit provides automatic frequency control when the oscillator is locked to the L.F.O.

The A.F.C. voltage on the lock line controls the bias on CRC 101 which determines its effective reactance as presented to the tank circuit. The potentiometer R114 is geared to the main tuning capacitor shaft to automatically reduce the A.F.C. voltage proportional to capacitor rotation. This produces an approximately equal locking range throughout the H.F.O. tuning range.

V105 is the buffer-output amplifier and the RF output is from the secondary of the tuned transformer T103 through J104 to the mixer-detector board in the audio chassis and from there to the input-output jack J701 on the front panel. The screen voltage for V105 is obtained from the audio chassis where it is caused to vary at a 1 KC rate when the function switch is in the modulation (MOD) position, thus modulating the RF output.

The 1 mc harmonic generator V101, supplies two outputs when driven with a 1 mc signal. The output from the secondary of the tuned transformer T101 in the suppressor grid circuit is used to drive the decade divider V201 in the 100 KC chassis.

The plate signal, a 1 mc pulse of high harmonic content, is fed to the synchronously tuned harmonic selector (V102) and amplifier (V103) from which the 23rd to 42nd harmonics are selected by the tuning capacitor C107.


VISUAL DETECTOR
AURAL DETECTOR
OUTPUT INPUT
22.176820 MC
LOCK VOLTAGE
REACTANCE CIRCUIT
AURAL AND VISUAL AMPLIFIER
BEAT DETECTOR
23 22 21
22
HARMONIC SELECTOR
MEGACYCLES (CONT VARI 20-40)
HF OSC AND BUFFER (20-40 MC) 22.176820 MC
1MC HARMONIC AMPLIFIER (23-42MC) 25 MC
CRYSTAL OSC (1MC)
HARMONIC SELECTOR
MIXER & IF AMPLIFIER (3-2 MC) 2.82318 MC
100KC HARMONIC AMPLIFIER (3.3-2.4 MC) 3.2 MC
DECADE DIVIDER (100 KC)
1
HUNDREDS OF KC 100KC STEPS (0-9)
100KC
MIXER & IF AMPLIFIER (300-400KC) 0.37682 MC
10 KC HARMONIC AMPLIFIER (350-440KC) 0.42 MC
DECADE DIVIDER (10KC)
7
TENS OF KC (10 KC STEPS) (0-9)
10KC
MIXER & IF AMPLIFIER (40-50KC) BROADBAND 43.18 KC
PHASE DISCR
L F OSC & BUFFER (50-40 KC) 43.18 KC
7
6.5
6.820
LOCK SWITCH
KILOCYCLES (CONT. VARI. 0-10)

The capacitor shaft of C107 is coaxial with that of C118 and a 1 mc harmonic selector control knob is located on the front panel. A coupling between the two shafts is provided such that the harmonic selector (C107) is carried to approximately the correct setting by the H.F.O. tuning capacitor C118, yet allowing an incremental adjustment to maximize the correct harmonic output.

The proper harmonic number (as explained in the operating instructions) when caused to appear in the harmonic selector window must be adjusted for maximum output as indicated by meter M701, which measures the rectified 1 mc harmonic signal appearing in the 100 KC chassis on the grid of the mixer tube V201.

The number appearing in the harmonic selector window is not the actual harmonic but is offset by 3 for simplicity of operation. The harmonic to be used is that which when mixed with the H.F.O. frequency will produce an intermediate frequency between 2 and 3 mc.

The harmonic output is taken from the secondary of the tuned transformer T102 through J103 and mixed with the H.F.O. output from J105 in the 100 KC chassis.

B. 100 KC AND 10 KC SELECTOR CHASSIS.

The 100 KC and 10 KC selector chassis contain almost identical circuitry. The only important difference is the frequencies involved. The following description of the 100 KC selector chassis should also serve for the 10 KC selector chassis.

The plate circuits of the mixer tube V203 and the I.F. amplifier V204 are synchronously tuned by switch sections C and D of S201, over the frequency range of 3-2 mc in ten 100 KC wide steps. The switch consecutively adds the trimmer capacitor in parallel to cover this range.

One of the ten switch positions will pass the intermediate frequency produced by the mixing of the H.F.O. and the properly selected 1 mc harmonic. The number of the switch position, (appearing in the window on the front panel) will be the hundreds of kilocycles of the measured or generated frequency.

The 4 gang switch S201 when rotated to the passband that accepts the intermediate frequency, automatically selects the correct 100 KC harmonic to be mixed with the output of V204 in the mixer V303 of the 10 KC selector chassis.

The decade divider V201 has an input of 1 mc (from an output of V101) and provides an output of 100 KC. The 100 KC square wave appearing in the plate circuit is differentiated and the resultant positive going pulse applied through the biased diode CR201 to the harmonic selector V202, tuned grid circuit. Switch sections S201A and S201B synchronously tune the grid and plate circuits in 10 steps to select and amplify the 33rd through the 24th harmonic of the 100 KC pulse.

A second output from the plate of V201 through R201 is the input to the decade divider (V301) in the 10 KC selector chassis.

Diode CR202, in the second control grid of V203, rectifies a portion of the 1 mc harmonic and the DC current through R214 to meter M701 indicates the proper adjustment of the 1 mc harmonic selector.

C. LOW FREQUENCY OSCILLATOR CHASSIS.

The Low Frequency Oscillator V403 is a transistron type oscillator variable over a frequency range of 40 to 50 KC by capacitor C423. Controls L403 and C421 are available on the front panel for calibration purposes. L403 is marked "at 10" and C421 "at 0". Proper adjustment of these controls will cause the frequency of the L.F.O. to be in exact relationship with the dial calibrations.

The L.F.O. output signal is taken from the capacitor divider C424 and C425 and fed to the phase splitter V404A, which in turn provides the driving signals for V405 whose push pull output is one input to the phase detector.

V401 is the mixer and V402 the I.F. amplifier. The resonant circuits in the plates are stagger tuned to provide a bandpass of 10 KC.

The 10 KC harmonic and I.F. output from the 10 KC step chassis are mixed and with a correct selection in the preceding steps, will produce an intermediate frequency between 40 and 50 KC.

Diode CR401 rectifies a portion of the I.F. from the 10 KC step chassis and the resultant D.C. is indicated on Meter M703 as a measure of the amount of signal present.

The phase of the 40-50 KC intermediate frequency from V402 and the phase of the L.F.O. frequency from V405 are compared in the phase detector. With the function switch in the lock position, the detector output voltage controls the reactance of CRC101 in the 20-40 mc oscillator of the H.F.O. chassis. The 20-40 mc. oscillator frequency is caused to change by the amount necessary to make the 40-50 KC intermediate frequency exactly the same as that of the L.F.O. variation cycle for cycle over the 10 KC range.

Cathode follower V404B provides two L.F.O. outputs. One is available through J404, a B.N.C. connector in the rear of the FM-6, for use with an external counter to improve the read out accuracy.

The second output through J405 goes to the audio section of the crystal oscillator and audio chassis, where it is beat with the 10 KC signal for the L.F.O. calibration.

Switch S401 converts the L.F.O. to a binary divider. With the 100 KC applied to the grid of V403, the output will be exactly 50 KC. As 50 KC represents zero on the dial, it is now possible to lock-up the FM-6 to any frequency between 20 mc and 40 mc in 10 KC increments. The FM-6 output frequency will be as accurate as the 1 mc source, which is 1 part in 10^7 using the internal 1 mc crystal.

The conversion switch is screwdriver operated from the front panel through an access hole located directly below the lettering "L.F.O.". When the dial is set to exactly 2.25

KC, the clearance hole in the dial is aligned properly for the insertion of the screwdriver.

The main tuning capacitor, calibrate controls and dial light are made electrically inoperative when the switch is in the crystal-controlled position.

D. CRYSTAL OSCILLATOR AND AUDIO CHASSIS

1. CRYSTAL OSCILLATOR

Tube V504 is the crystal oscillator and V503 the buffer amplifier. The signal at the plate of V503 is rectified negative by CR505 and a portion of the DC voltage is used as a bias on the oscillator tube V504 for automatic gain control. R540 controls the amount of AGC bias applied to the grid of V504 and is used to set the output of T502 to approximately 5V P.P. R517, in the cathode circuit of V503, also controls the overall gain and is adjusted to make the crystal drive on the grid (pin 1) of V504 to be not more than 1.5V p.p.

The crystal is tuned by a series-parallel combination of capacitors. Capacitors C522 and C523 are used for 'fine' frequency adjustment. If, due to crystal aging, a larger capacity change is needed, one or more of capacitors C527 through C530 may be deleted from the circuit as shown in detail 'A' on the schematic diagram. The 'fine' frequency adjust capacitors will have enough range to overlap 'one step' of the 'coarse' frequency control of detail 'A'. The coarse control capacitors (C527 through C530) are located on a small terminal board mounted inside the chassis next to the crystal oven socket.

The 5V P.P. output on the secondary of T502 is connected to the internal-external 1 MC switch, S701, on the front panel. In either position of the switch, the 1 MC output is available at J702. (1 MC output)

2. AUDIO SECTION

The audio section contains the mixer-detector board, function switch, two stages of audio voltage amplification (V501), cathode follower (V502A), power output stage (V502B) and a lock voltage VTVM (V505).

The output of the H.F.O. at J503 is applied to the harmonic generating diode CR501, and the signal is then mixed with the frequency present at J504 (input-output) and the beat note detected by diode CR502. The beat note is then fed to the beat note amplifier by the function switch (S501) in the beat and lock positions.

A harmonic rich 10 KC signal from the decade divider (V301) and the L.F.O. output frequency are also supplied to the mixer-detector board through J502 and J501. In the calibrate position (CAL) of the function switch, the two signals are mixed and the beat note detected by diode CR503 then fed to the beat note amplifier. An RC filter (R505 and C504) is used to reduce the 10 KC signal present in the output of the detector.

The beat note, after amplification by V501, is direct coupled to the first half of V502, a cathode follower. The beat note signal present at the cathode is then capacity coupled to the beat indicator meter M705 which will visually indicate the beat note signal to far below the audible range.

The signal at the junction of R511 and R538 is capacity coupled to the volume control (R513) to drive the audio output stage V502B.

The function switch (S501), when in the modulation (MOD) position, converts the output stage to a blocking oscillator. The wave shape is modified to approximate a sine wave by an RC network in the feedback path and the resultant signal at the plate is used to screen modulate the H.F.O. buffer stage.

The lock position of the function switch is identical to the beat position except that the short to ground on the lock line is removed by S501F. V505, the lock voltage VTVM will now indicate the amount and polarity of the A.F.C. voltage present to maintain the correct frequency of the H.F.O. Control R535 is used to adjust the meter to center position when the function switch is in any but lock position.

E. POWER SUPPLY.

Plate and heater power (except crystal oven) for the FM-6 is provided by a single power transformer T601. The primary is wound with two equal 115 V windings that can be connected either in parallel for 115 V operation or in series for 230 V operation. Binding posts and straps, TB601, are provided for a simple change over to either voltage.

The 220 V AC from the secondary winding is rectified by four plug-in type silicon rectifiers in a full wave bridge circuit.

Standby switch S602 interrupts the 220 V AC to the bridge rectifier but allows the crystal oven and tube heater circuits to operate normally.

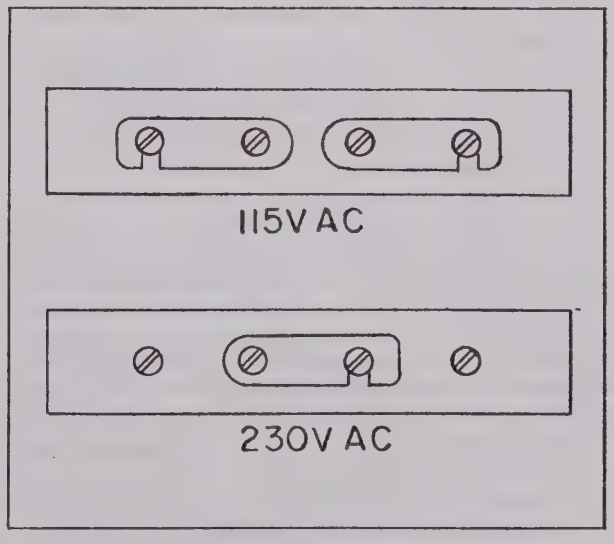


FIGURE 5 115/230V AC CONNECTIONS

The D.C. voltage (+ 150 V nominal) furnished by the power supply is regulated. A gas diode V603 is the reference source and V602 is the D.C. amplifier. The series regulator V601 is shunted by R602 to reduce the amount of load current through it.

The regulation is necessary primarily to reduce the internal impedance of the supply. For this reason the actual voltage is not too important and precise adjustment is not needed.

The voltage should measure somewhere between +145 and +155 Volts.

The unit is normally connected for 115 V AC operation and is supplied with a 1 ampere fuse. If used in 230 V AC, the fuse should be changed to one of ½ ampere rating.

SECTION IV
MAINTENANCE

1. SELF CHECKING AND ALIGNMENT.

The FM-6 possesses many self checking features and it is possible to correct almost all minor misalignment due to tube changes, aging of components etc., without the need of additional test equipment.

A. HIGH FREQUENCY OSCILLATOR.

(1) Remove the 1 mc harmonic output tube (V103).

(2) Connect a short coaxial cable between the 1 mc output and the INPUT-OUTPUT jack.

(3) Connect a short clip lead across the 10K resistor that is in series with the 1 mc output jack.

(4) Rotate the H.F.O. dial and a beat note will be heard at every megacycle point.

(5) If dial tracking is off, adjust C120 and C130 at the 40 mc end and L105 and T103 at the 20 mc point.

(6) Replace V103 and set the 100 KC selector dial to zero.

(7) Set the 1 mc HARMONIC SELECTOR dial to 38 and the H.F.O. dial to 38 mc and rotate slightly to get maximum reading on the 100 KC selector meter.

(8) Adjust C130 to get a maximum 100 KC selector meter reading.

(9) Set the 1 mc HARMONIC SELECTOR dial to 22 and the H.F.O. dial to 22 mc as in Step 6.

(10) Adjust T103 to get a maximum 100 KC selector meter reading.

B. 1 MC HARMONIC SELECTOR.

With the 100 KC selector switch set at 5 and the H.F.O. dial set to approximately 22.5 mc, the 1 mc harmonic selector should cause a peak reading on the harmonic selector meter and 100 KC selector meter when the number 22 is centered in the window. Peak meter readings should also be obtained when the H.F.O. is set to 38.5 mc and the 1 mc harmonic has the number 38 centered. If the centering is off enough to warrant it, the following procedure can be used for re-alignment.

(1) Set the H.F.O. dial to 38.5 mc and center the number 38 in the 1 mc HARMONIC selector window.

(2) Set KC selector dial to 5.

(3) Adjust C108 and C114 to give maximum reading on the 1 mc HARMONIC selector meter. This should also produce a maximum reading on the 100 KC selector dial, which insures the correct harmonic has been chosen.

(4) Set H.F.O. dial to 22.5 mc and the 1 mc HARMONIC selector to center the number 22 in the window.

(5) Adjust L102 and T102 for maximum reading on the meters as in Step 3.

(6) Repeat Steps 1 through 5, if necessary.

C. 100 KC SELECTOR CHASSIS.

1. 100 KC SELECTOR I.F.

Set up and lock a frequency of 30.095 mc as per operating instructions. As the 10 KC selector is switched from 9 through 0 and locked on each setting, the 100 KC selector meter reading will indicate the bandpass of position zero of the 100 KC chassis I.F. The bandpass should be essentially symmetrical. Each 100 KC passband (position 0-9) can be checked in this manner. If the bandpasses are too unsymmetrical, they can be realigned as in the following:

(1) Set up and lock the FM-6 to generate a frequency of 30.055 mc.

(2) Adjust the two I.F. trimmer capacitors marked 0, in the two groups of trimmers nearest the front panel, to give a maximum 100 KC selector meter reading.

(3) Reset the 100 KC selector switch to 1 and re-establish lock.

(4) Adjust the I.F. trimmer capacitors marked 1 as in Step 2.

(5) Continue to adjust each set of I.F. trimmers 0 through 9 in this order, as in Steps 2, 3, and 4.

2. 100 KC SELECTOR HARMONICS.

(1) Set up and lock a frequency of 30.050 mc on the FM-6.

(2) Adjust the two 100 KC harmonic selector trimmer capacitors marked 0 in the two groups of trimmers toward the rear of the chassis for a maximum reading on the 10 KC selector meter.

(3) Change the 100 KC selector switch to position 1 and adjust the H.F.O. to re-establish lock.

(4) Adjust the two 100 KC harmonic selector trimmer capacitors marked 1 as in Step 2.

(5) Continue to adjust each set of trimmers, 0 through 9, and in that order, as in Steps 2, 3 and 4.

This alignment may be performed in most cases even if the L.F.O. chassis is not functioning properly and a lock cannot be obtained. The frequency is set up the same as in Step 1 above and the H.F.O. is adjusted to give maximum output on the 10 KC selector meter each time the 100 KC selector is changed.

The use of the 10 KC selector meter indication (or lock, if possible) insures the correct frequency is being peaked each time. If the 10 KC selector chassis is not functioning properly, the alignment procedure outlined above will not work and some other means of measuring the intermediate frequencies and 100 KC harmonics will be necessary. A table showing the correct frequencies appears on the 100 KC selector chassis schematic Fig. 7.

3. 100 KC DECADE DIVIDER.

There are two methods to determine whether the decade divider is performing the proper division. A frequency counter can be used to measure the 100 KC output signal appearing on J201. This output is direct coupled to the plate of V201 through a resistor and the DC plate voltage will also be present. The second method is to connect an oscilloscope probe to the cathode (Pin No. 2) of V201. The waveform present is the sum of the input and output signals. There should be exactly 10 cycles of the 1 MC input signal appearing during the time for one cycle of the output signal (100 KC).

If either method indicates an incorrect division, L201 should be readjusted. As the L201 is adjusted it will be noted that a locking range exists where a small adjustment of the slug will not change the division rate. The limits of the locking range should be noted and the slug set to a position midway between the two.

The locking range should be at least ½ turn total on the 100 KC coil and 1½ turns on the 10 KC coil. Due to the wide variations in 6AS6 transconductances, a positive bias is required to optimize the circuit operation for the widest possible locking range.

The optimum setting is best determined by observing the plate on Pin No. 5 with an oscilloscope. With the bias initially set to zero (maximum clockwise), increase the bias until the waveform shows an absence of sync signal (1 mc or 100 KC) on the positive excursion of the waveform. The bias can be anywhere between 0 and 1.5.V and in most cases will be about 0.7V.

D. 10 KC SELECTOR CHASSIS.

1. 10 KC SELECTOR I.F.

Calibrate the L.F.O. and set up and lock a frequency of 30.595 mc as per operating instructions.

When the L.F.O. dial is rotated from 0 through 10 the bandpass of position 9 of the 10 KC chassis I.F. is indicated by the 10 KC selector meter and should be essentially symmetrical. Each passband (0-9) can be checked in this manner. If the passbands are too unsymmetrical, they can be realigned as in the following.

(1) Set up and lock the FM-6 to generate a frequency of 30.595 mc.

(2) Adjust the two I.F. trimmer capacitors marked 9 in the two groups of trimmers nearest the front panel to give a maximum 10 KC selector meter reading.

(3) Reset the 10 KC selector switch to 8 and re-establish lock.

(4) Adjust the I.F. trimmer capacitors marked 8 as in Step 2.

(5) Continue to adjust each set of I.F. trimmers 9 through 0 (in this order) as in Steps 2, 3 and 4.

2. 10 KC SELECTOR HARMONICS.

To peak the 10 KC selector harmonic amplifiers it will be necessary to have some auxiliary means to indicate the relative amplitude of the L.F.O. intermediate frequency. An oscilloscope capable of showing 40-50 KC at approximately 40 volts peak to peak or a high input impedance AC VTVM may be used.

The following procedure should be used.

(1) Set up and lock a frequency of 30.595 mc on the FM-6.

(2) Connect the oscilloscope or VTVM to the junction of C412, R411 and R414. These components are located on the terminal board on the rear wall of the L.F.O. chassis.

(3) Adjust the two harmonic selector trimmer capacitors marked 9 in the two groups of trimmers toward the rear of the chassis, for maximum indication.

(4) Change the 10 KC selector switch to position 8 and reset the H.F.O. to re-establish lock.

(5) Adjust the two harmonic selector trimmer capacitors marked 8 as in Step 3.

(6) Continue to adjust each set of trimmers, 9 through 0, and in that order, as in Steps 3, 4 and 5.

If the L.F.O. chassis is not functioning properly and lock cannot be obtained, the alignment procedures outlined above will not work. Some other means of measuring the intermediate frequencies will be necessary. A table showing the correct frequencies appears on the 10 KC selector chassis schematic Fig. 8.

3. 10 KC DECADE DIVIDER.

The correct operation of this circuit can be determined in the same manner as that used for the 100 KC decade divider and described in section C paragraph 3.

E. LOW FREQUENCY CHASSIS.

1. LOW FREQUENCY OSCILLATOR (LFO).

With the FUNCTION SWITCH in the CAL position,

the two front panel controls (L403 and C421) should have sufficient range to bring the L.F.O. dial into calibration. If the controls do not have the necessary range, L404 and C423 must be re-adjusted.

After a half-hour warm up period, set both front panel controls to their mid-range and adjust L404 and C423 to obtain correct dial calibration.

2. BROAD BAND 40-50 KC I.F.

To realign the I.F. an oscilloscope or VTVM will be necessary to monitor the same point as for the 10 KC harmonic selector adjustments.

If the I.F. is not too far out of alignment and a lock can be obtained, rotating the L.F.O. dial from 0 to 10 will vary the I.F. from 50 to 40 KC. L401 is peaked at 51 KC and L402 at 39 KC.

In the case where alignment is such that the FM-6 will not lock, the L.F.O. output on J404 or J405 can be fed directly into the mixer tube (V401) through J402. After a rough alignment is made and the FM-6 will lock, the first method should be used for final touch-up.

3. CRYSTAL-CONTROLLED L.F.O.

To adjust the L.F.O. to divide by 2 in the crystal-controlled position, an oscilloscope will be necessary.

(a) Connect the oscilloscope probe to the 100 KC chassis test point TP201 and the L.F.O. output from J404 to the horizontal input of the oscilloscope.

(b) Place switch S401 in the crystal-controlled position as evidenced by the dial light being extinguished.

(c) Adjust C434 until a stable 2:1 lissajous pattern is present.

(d) Note the limits of the capacitor adjustment and set to midway between.

As a further check for proper alignment, there should be no beat note present when the function switch is in the CAL position.

F. CRYSTAL OSCILLATOR CHASSIS.

The B.N.C. connector labeled 1 MC OUTPUT is the output from the internal 1 mc crystal oscillator and is present at all times.

To adjust the frequency of the 1 mc crystal oscillator a snap-out plug on the left side of the FM-6 case gives access to the trimmer capacitors from the outside.

The preferred method of adjusting the frequency is by comparison to a secondary standard with a Lissajous pattern or using the 1 mc output as a sync for an oscilloscope. An audible beat note type of adjustment will not give the required accuracy. Any one or all of the four trimmer capacitors may be adjusted to stop the oscilloscope pattern.

The crystal oscillator should not be adjusted until after at least a one hour warm up period.

A method of calibrating the 1 mc crystal oscillator to WWV, using a communications receiver is as follows:

Tune the receiver to WWV on either 15 mc or 20 mc. Couple the FM-6 1 mc crystal output (J507 or J702) through a 5-25 uuf trimmer capacitor to the receiver antenna connector. Adjust the trimmer capacitor to get the maximum beat note amplitude as indicated by the S meter. An alternate beat note indicator can be an oscilloscope very lightly coupled (1 or 2 uuf) to the receiver 2 nd I.F.

The 1 mc crystal oscillator trimmer capacitors can then be adjusted to the lowest observable beat note frequency.

A beat note frequency of one cycle per second, (timed with a watch) will give a comparison accuracy of 5 parts in 10^8 if the receiver is tuned to 20 mc or 6.67 parts in 10^8 if tuned to 15 mc.

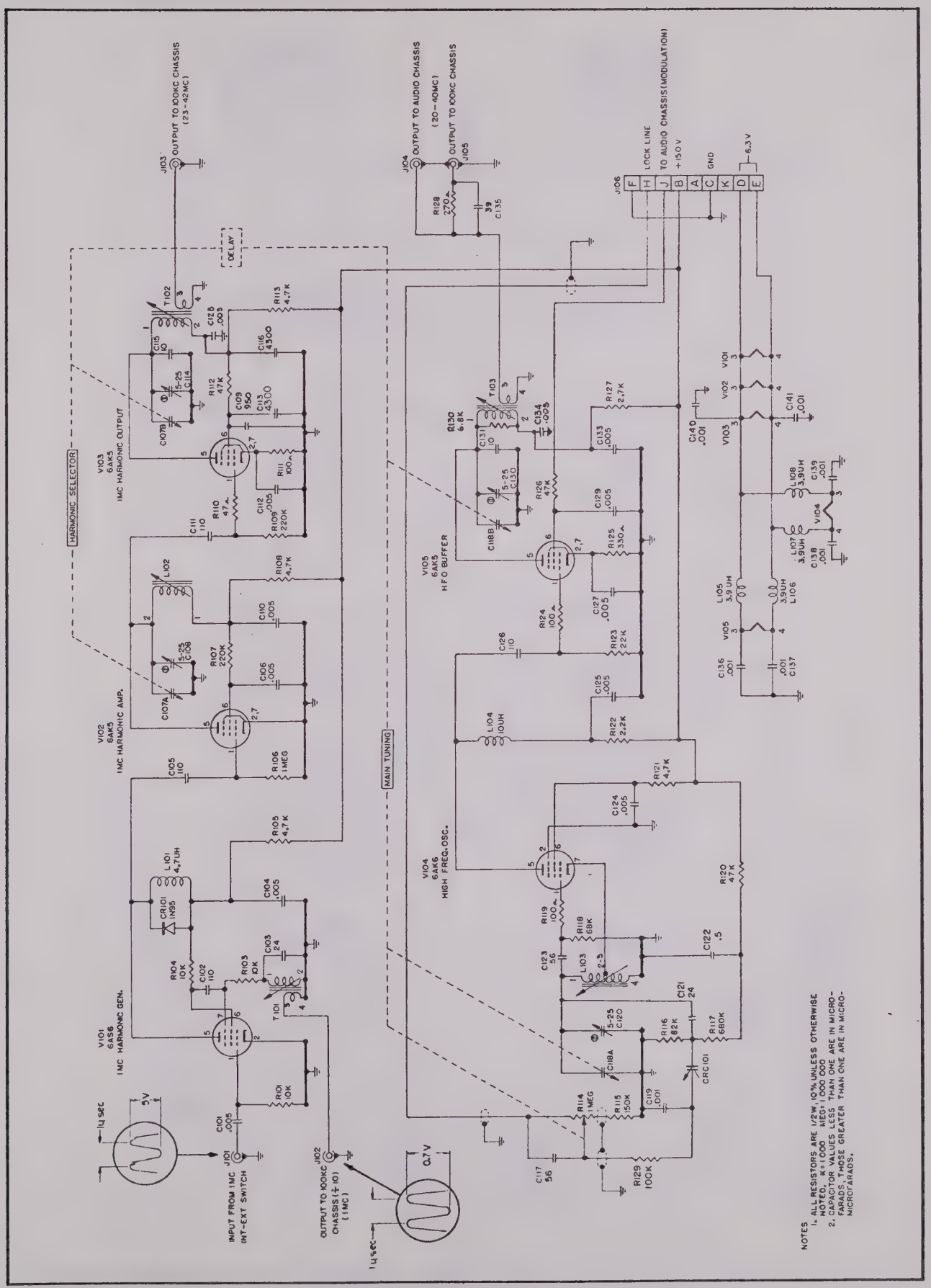

HARMONIC SELECTOR
MAIN TUNING
DELAY
V101 6AS6 IMC HARMONIC GEN.
V102 6AK5 IMC HARMONIC AMP.
V103 6AK5 IMC HARMONIC OUTPUT
V104 6AK6 HIGH FREQ. OSC.
V105 6AK5 H.F.O. BUFFER
J101 INPUT FROM IMC INT-EXT SWITCH
J102 OUTPUT TO 100KC CHASSIS (÷10) (1MC)
J103 OUTPUT TO 100KC CHASSIS (23-42MC)
J104 OUTPUT TO AUDIO CHASSIS (20-40MC)
J105 OUTPUT TO 100KC CHASSIS
J106 LOCK LINE, TO AUDIO CHASSIS (MODULATION), +150 V, GND, 6.3 V
1 μsec
5 V
0.7 V
NOTES
1. ALL RESISTORS ARE 1/2W, 10% UNLESS OTHERWISE NOTED. K=1,000 OHMS, MEG=1,000,000 OHMS.
2. CAPACITOR VALUES LESS THAN ONE ARE IN MICROFARADS, THOSE GREATER THAN ONE ARE IN MICROMICROFARADS.

FIG. 6. SCHEMATIC, HIGH FREQUENCY OSCILLATOR AND HARMONIC AMPLIFIER CHASSIS

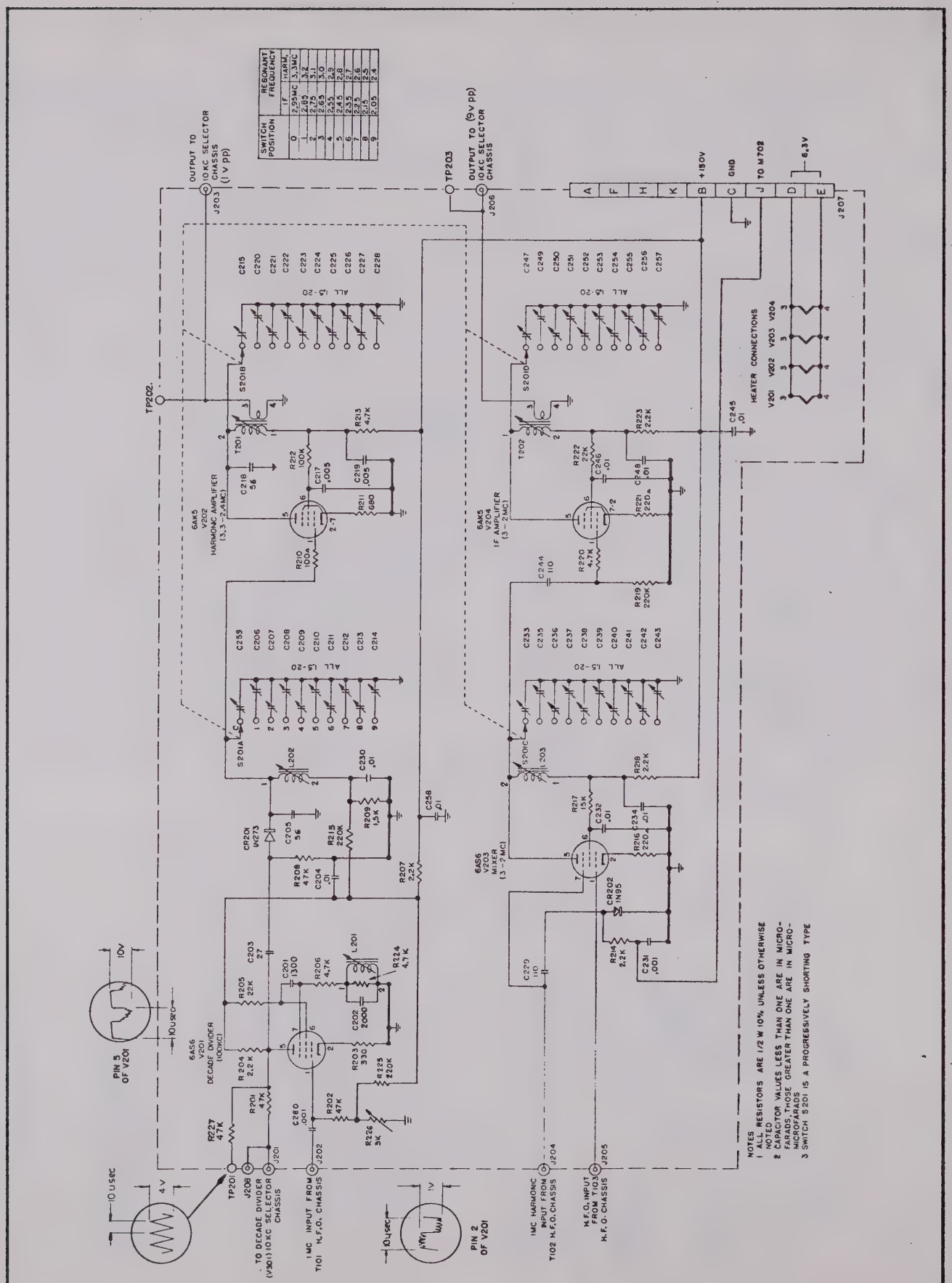


FIG. 7. SCHEMATIC, 100 KC SELECTOR CHASSIS

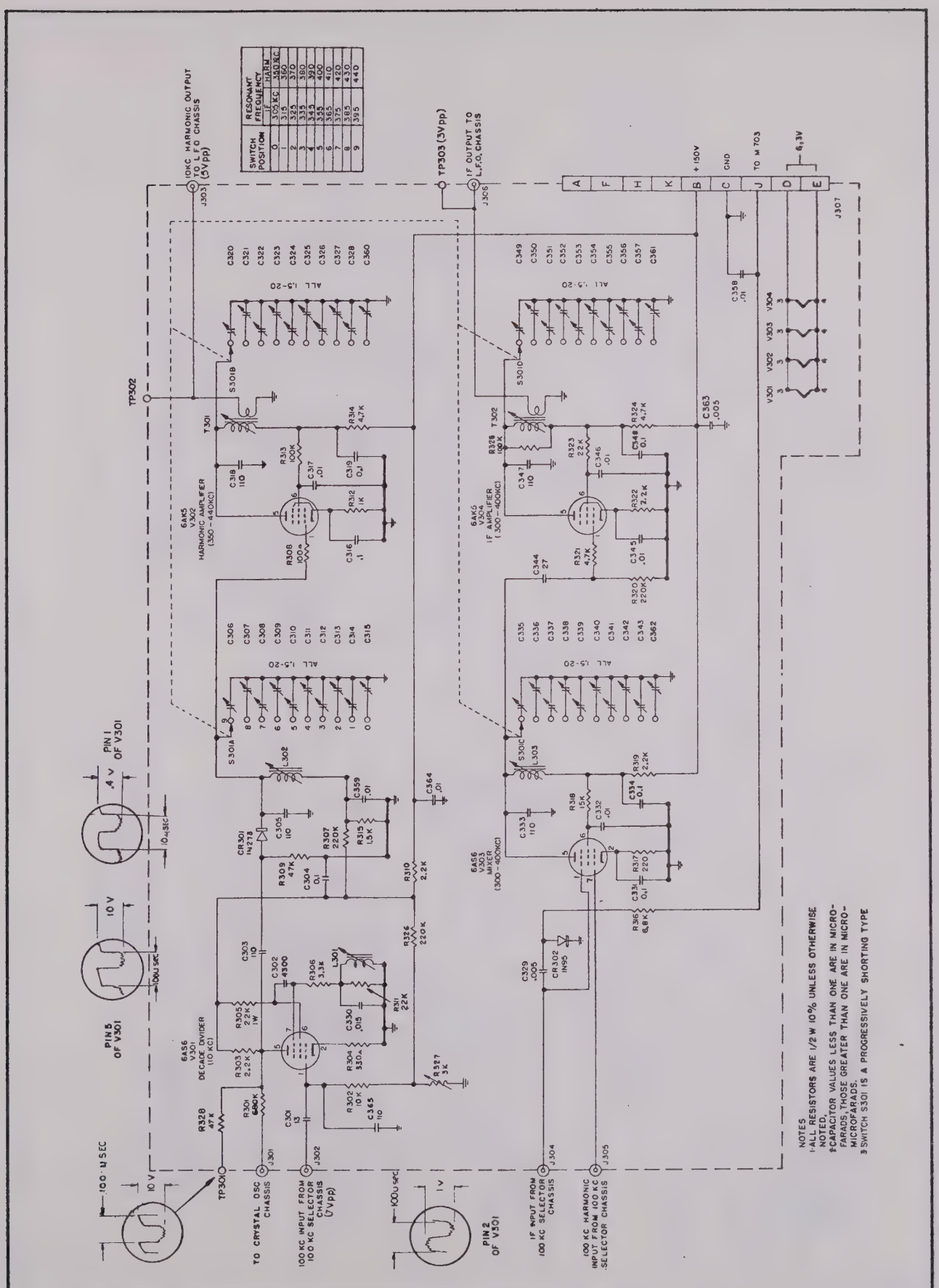


FIG. 8. SCHEMATIC, 10 KC SELECTOR CHASSIS

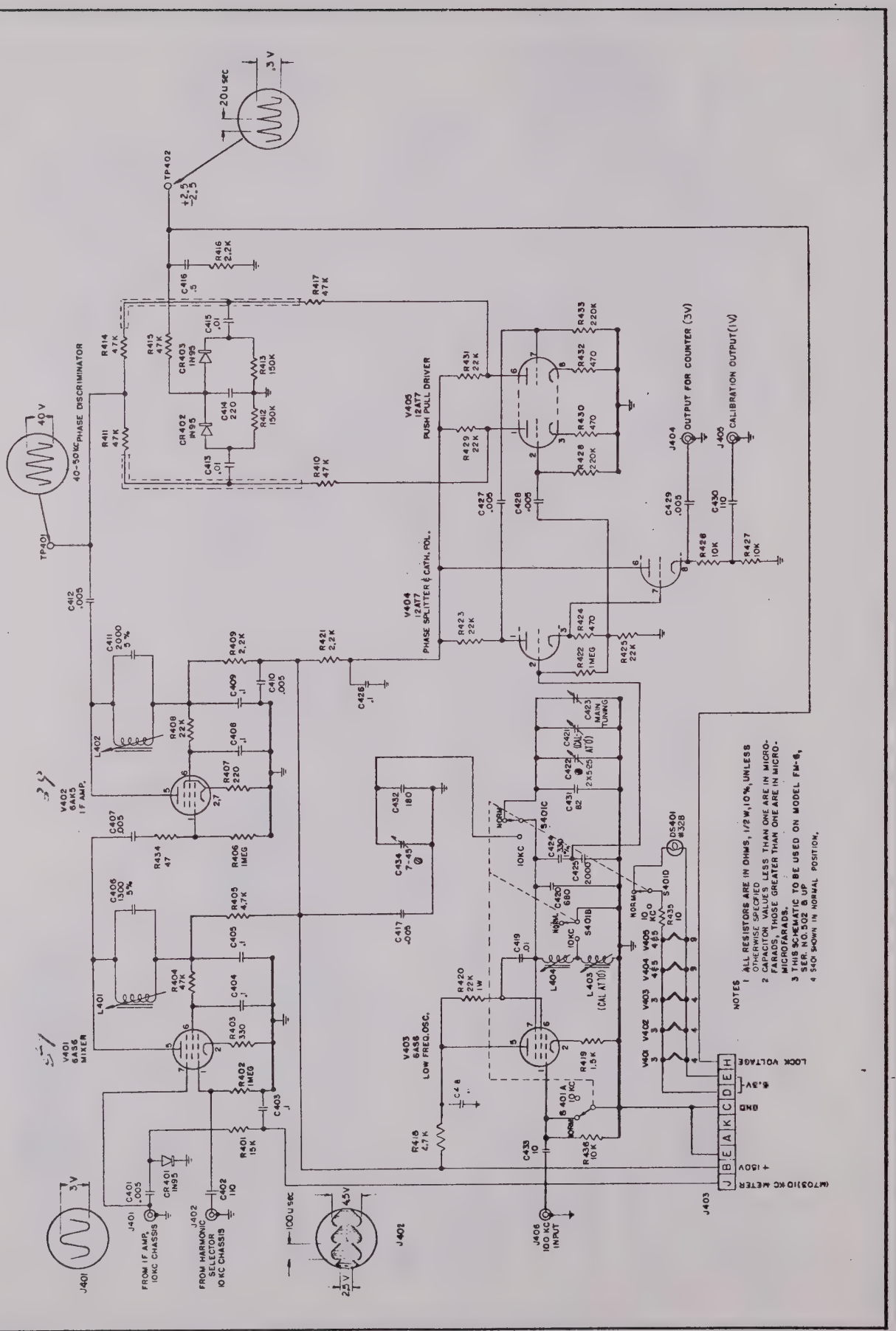
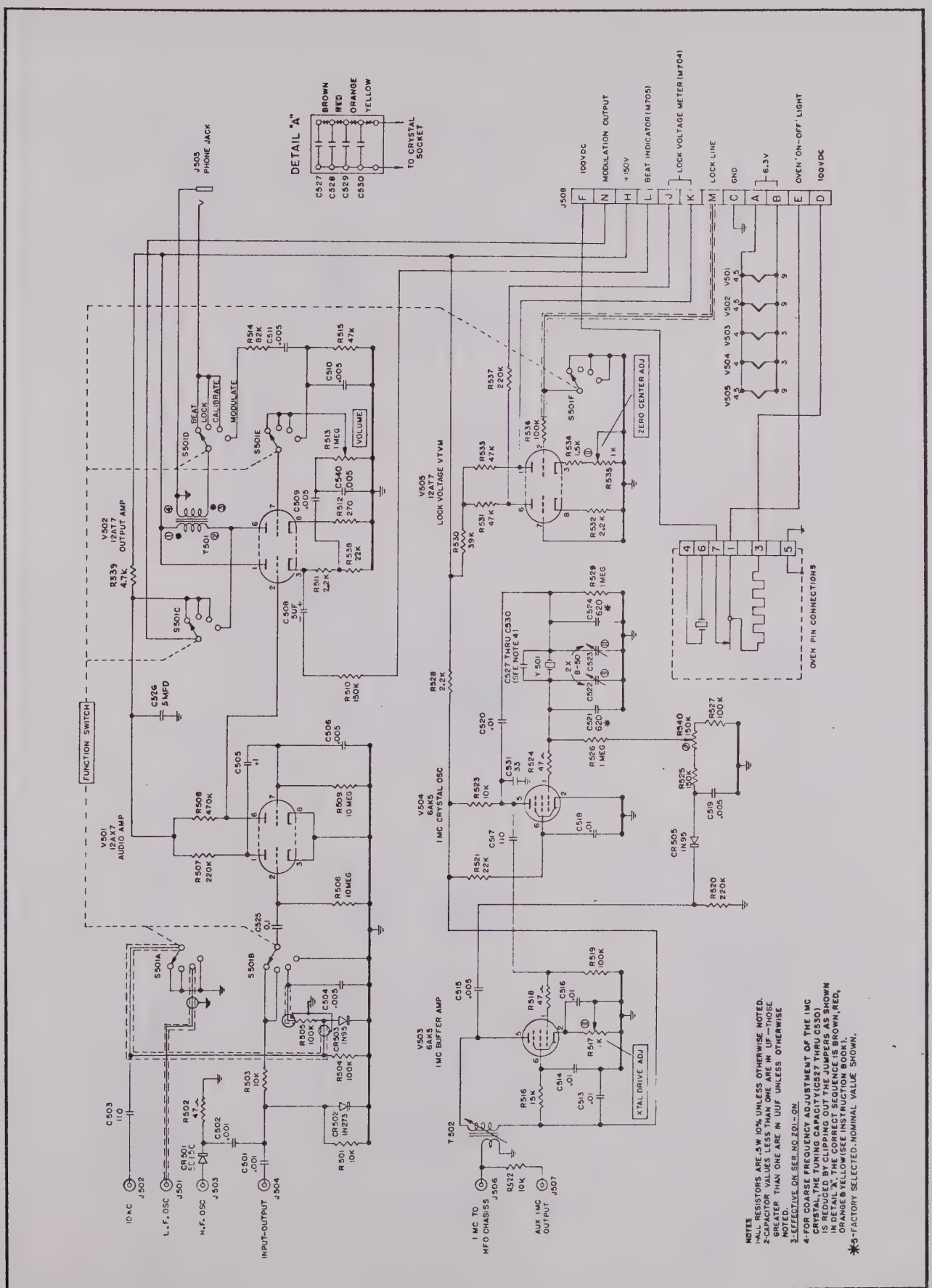

V401 6AS6 MIXER
V402 6AK5 IF AMP.
V403 6AS6 LOW FREQ. OSC.
V404 12AT7 PHASE SPLITTER & CATH. FOL.
V405 12AT7 PUSH PULL DRIVER
40-50KC PHASE DISCRIMINATOR
OUTPUT FOR COUNTER (3V)
CALIBRATION OUTPUT (1V)
FROM IF AMP. 10KC CHASSIS
FROM HARMONIC SELECTOR 10 KC CHASSIS
100 KC INPUT
LOCK VOLTAGE
+150V
6.3V
GND
NOTES
1 ALL RESISTORS ARE IN OHMS, 1/2W, 10%, UNLESS OTHERWISE SPECIFIED
2 CAPACITOR VALUES LESS THAN ONE ARE IN MICROFARADS, THOSE GREATER THAN ONE ARE IN MICROMICROFARADS.
3 THIS SCHEMATIC TO BE USED ON MODEL FM-8, SER. NO. 502 & UP
4 S401 SHOWN IN NORMAL POSITION.

FIG. 9. SCHEMATIC, LOW FREQUENCY OSCILLATOR CHASSIS (SERIAL NO. 502 & UP)



NOTES:
1-ALL RESISTORS ARE .5W 10% UNLESS OTHERWISE NOTED.
2-CAPACITOR VALUES LESS THAN ONE ARE IN UF—THOSE GREATER THAN ONE ARE IN UUF UNLESS OTHERWISE NOTED.
3-EFFECTIVE ON SER. NO. 201 - ON.
4-FOR COARSE FREQUENCY ADJUSTMENT OF THE IMC CRYSTAL, THE TUNING CAPACITY (C527 THRU C530) IS REDUCED BY CLIPPING OUT THE JUMPERS AS SHOWN IN DETAIL "A". THE CORRECT SEQUENCE IS BROWN, RED, ORANGE & YELLOW (SEE INSTRUCTION BOOK).
*5-FACTORY SELECTED. NOMINAL VALUE SHOWN.

FIG. 10. SCHEMATIC, CRYSTAL OSCILLATOR AND AUDIO CHASSIS

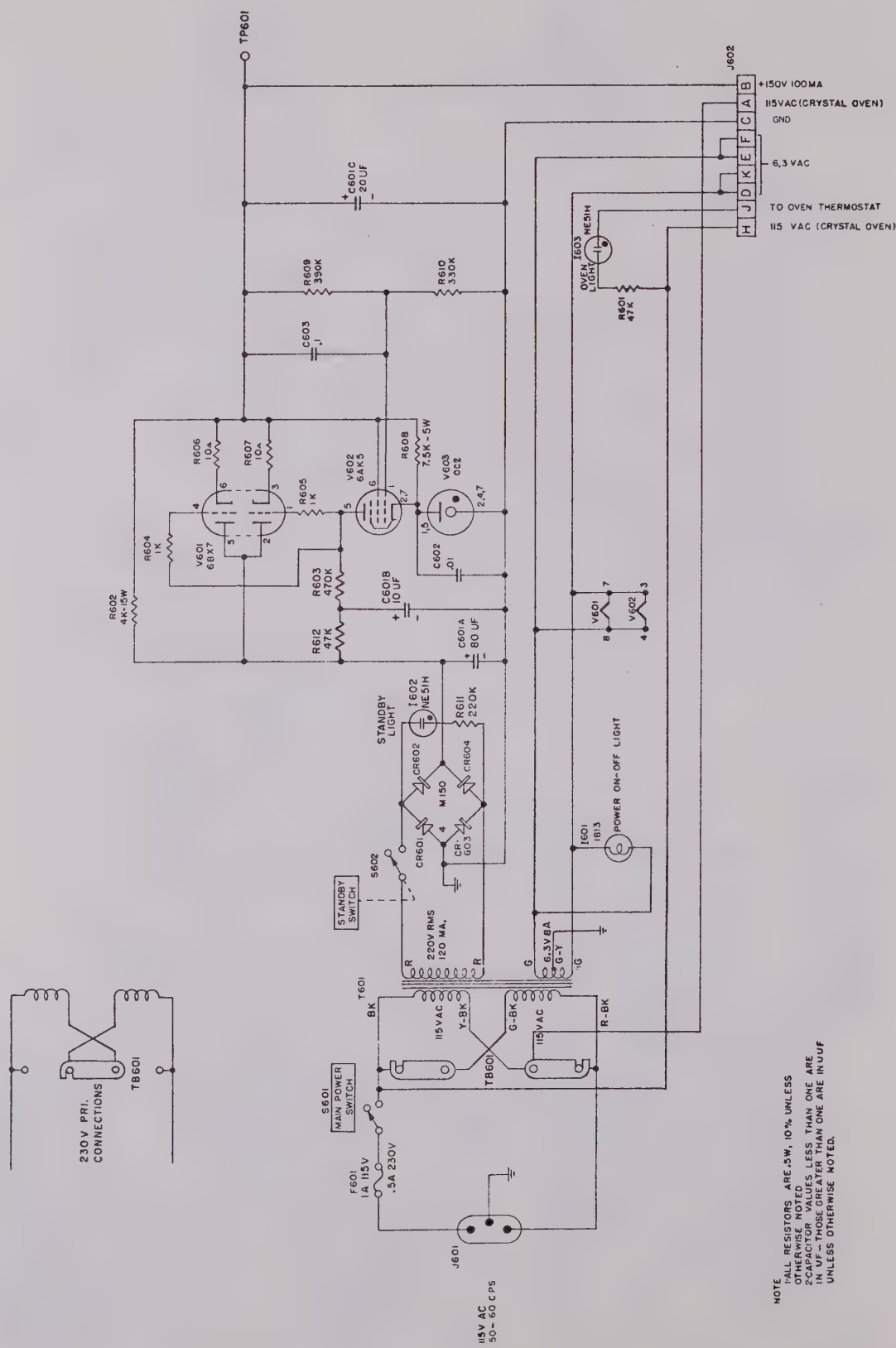


FIG. 11. SCHEMATIC, POWER SUPPLY CHASSIS

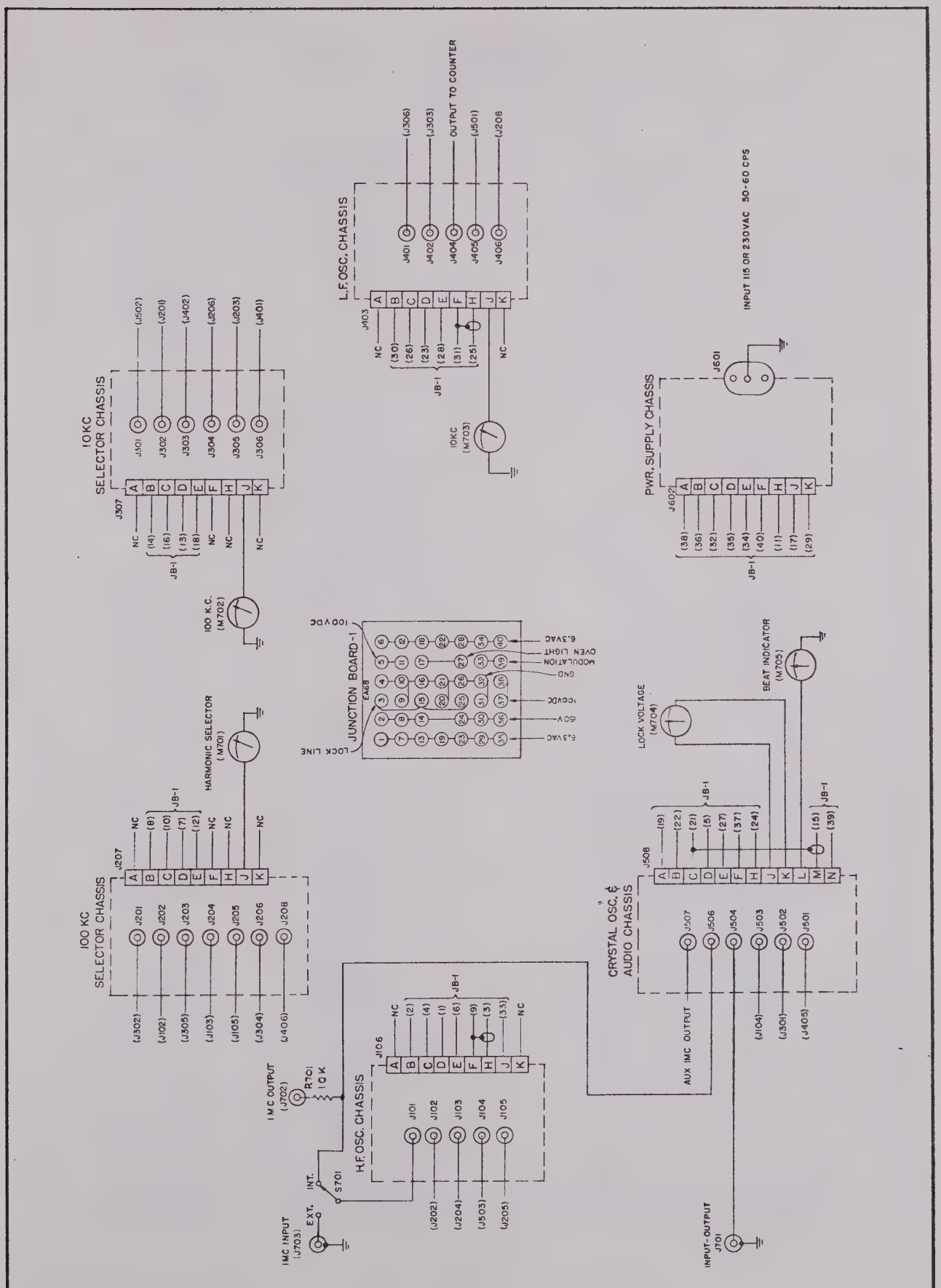


FIG. 12. INTERCONNECTING CABLE BLOCK WIRING DIAGRAM

SECTION V
PARTS LIST

H. F. O. & HARMONIC AMPLIFIER

SYM-BOL	DESCRIPTION	MANUFACTURER	PART NO.
C101	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C102	Capacitor, mica 110 pF	Elmenco	DM15E111J
C103	Capacitor, mica 24 pF	Elmenco	DM15E240J
C104	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C105	Capacitor, mica 110 pF	Elmenco	DM15E111J
C106	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C107	Capacitor, variable air	GPI	CA3-2
C108	Capacitor, variable ceramic 5-25 pF	GPI	CA6
C109	Capacitor, mica 950 pF	Elmenco	DM19E951J
C110	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C111	Capacitor, mica 110 pF	Elmenco	DM15E111J
C112	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C113	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C114	Capacitor, variable ceramic 5-25 pF	GPI	CA6
C115	Capacitor, ceramic 10 pF	Centralab	TCN10
C116	Capacitor, mica 4300 pF	Elmenco	DM20E432J
C117	Capacitor, mica 56 pF	Elmenco	DM15E560J
C118	Capacitor, variable air	GPI	CA3-1
C119	Capacitor, ceramic .001 uF	Erie	861Z5U102Z
C120	Capacitor, variable ceramic 5-25 pF	GPI	CA6
C121	Capacitor, mica 24 pF	Elmenco	DM15E240J
C122	Capacitor, paper .5 uF	Hopkins Eng.	P52DS
C123	Capacitor, mica 56 pF	Elmenco	DM15E560J
C124	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C125	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C126	Capacitor, mica 110 pF	Elmenco	DM15E111J
C127	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C128	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C129	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C130	Capacitor, variable ceramic 5-25 pF	GPI	CA6
C131	Capacitor, ceramic 10 pF	Centralab	TCN10
C133	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C134	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C135	Capacitor, ceramic 39 pF	Erie	831N1500-39K
C136	Capacitor, ceramic .001 uF	Erie	861Z5U102Z
C137	Capacitor, ceramic .001 uF	Erie	861Z5U102Z
C138	Capacitor, ceramic .001 uF	Erie	861Z5U102Z
C139	Capacitor, ceramic .001 uF	Erie	861Z5U102Z
C140	Capacitor, ceramic .001 uF	Erie	861Z5U102Z
C141	Capacitor, ceramic .001 uF	Erie	861Z5U102Z

SYM-BOL	DESCRIPTION	MANUFACTURER	PART NO.
CR101	Diode	Hughes	1N95
CRC101	Diode, capacitor	Pacific Semiconductor	V20
J101 thru J105	Connector, receptacle (5 req'd.)	GPI	SPM1
J106	Connector, receptacle	Amphenol	126-219
L101	Choke 4.7 uH	Miller	6081-4-7
L102	Coil, variable .25 - .37 uH	GPI	LS25-4
L103	Coil, variable .35 - .59 uH	GPI	LS25-1
L104	Choke 10 uH	Miller	6081-10
L105	Choke 3.9 uH	Miller	6081-3-9
L106	Choke 3.9 uH	Miller	6081-3-9
L107	Choke 3.9 uH	Miller	6081-3-9
L108	Choke 3.9 uH	Miller	6081-3-9
R101	Resistor, composition 10K 10% ½W		
R103	Resistor, composition 10K 10% ½W		
R104	Resistor, composition 10K 10% ½W		
R105	Resistor, composition 4.7K 10% ½W		
R106	Resistor, composition 1 mego 10% ½W		
R107	Resistor, composition 220K 10% ½W		
R108	Resistor, composition 4.7K 10% ½W		
R109	Resistor, composition 220K 10% ½W		
R110	Resistor, composition 47 ohms 10% ½W		
R111	Resistor, composition 100 ohms 10% ½W		
R112	Resistor, composition 47K 10% ½W		
R113	Resistor, composition 4.7K 10% ½W		
R114	Resistor, variable 1 mego	GPI	RV12
R115	Resistor, composition 150K 10% ½W		
R116	Resistor, composition 82K 10% ½W		
R117	Resistor, composition 680K 10% ½W		
R118	Resistor, composition 68K 10% ½W		
R119	Resistor, composition 100 ohms 10% ½W		
R120	Resistor, composition 47K 10% ½W		
R121	Resistor, composition 4.7K 10% ½W		
R122	Resistor, composition 2.2K 10% ½W		
R123	Resistor, composition 22K 10% ½W		
R124	Resistor, composition 100 ohms 10% ½W		
R125	Resistor, composition 330 ohms 10% ½W		
R126	Resistor, composition 47K 10% ½W		
R127	Resistor, composition 2.7K 10% ½W		
R128	Resistor, composition 270 ohms 10 % ½W		
R129	Resistor, composition 100K 10% ½W		
R130	Resistor, composition 6.8K 10% ½W		
T101	Transformer, variable .3 - 1 mH	GPI	LS25-3
T102	Transformer, variable .26 - .42 mH	GPI	LS25-5

SYM-BOL	DESCRIPTION	MANUFACTURER	PART NO.
T103	Transformer, variable .3 - .51 mH	GPI	LS25-2
V101	Electron tube		6AS6
V102	Electron tube		6AK5
V103	Electron tube		6AK5
V104	Electron tube		6AK6
V105	Electron tube		6AK5
XV101 thru XV105	Socket, tube (5 req'd.)	Cinch	53C24761
	100 KC CHASSIS		
C201	Capacitor, mica 1300 pF	Elmenco	DM19E132J
C202	Capacitor, mica 2000 pF	Elmenco	DM19E202J
C203	Capacitor, ceramic 27 pF	Erie	831N750-27K
C204	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C205	Capacitor, mica 56 pF	Elmenco	DM15E560J
C206 thru C214	Capacitor, var mica 1.5 - 20 pF (5 trimmers per assy. 2 req'd.)	GPI	CM3
C215	Capacitor, var mica 1.5 - 20 pF (part of C220)		
C217	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C218	Capacitor, mica 56 pF	Elmenco	DM15E560J
C219	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C220 thru C228	Capacitor, var mica 1.5 - 20 pF (5 trimmers per assy. 2 req'd.)	GPI	CM3
C229	Capacitor, mica 110 pF	Elmenco	DM15E111J
C230	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C231	Capacitor, ceramic .001 uF	Erie	861Z5U102Z
C232	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C233	Capacitor, var mica 1.5 - 20 pF (part of C235)		
C234	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C235 thru C243	Capacitor, var mica 1.5 - 20 pF (5 trimmers per assy. 2 req'd.)	GPI	CM3
C244	Capacitor, mica 110 pF	Elmenco	DM15E111J
C245	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C246	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C247	Capacitor, var mica 1.5 - 20 pF (part of C235)		
C248	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C249 thru C257	Capacitor, var mica 1.5 - 20 pF (5 trimmers per assy. 2 req'd.)	GPI	CM3
C258	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C259	Capacitor, var mica 1.5 - 20 pF (part of C206)		
C260	Capacitor, ceramic .001 uF	Erie	861Z5U102Z
CR201	Diode	Transitron	IN273
CR202	Diode	Hughes	IN95
J201 thru J206	Connector, receptacle (6 req'd.)	GPI	SPM1

SYM-BOL	DESCRIPTION	MANUFACTURER	PART NO.
J207	Connector, receptacle	Amphenol	126-219
J208	Connector, receptacle	GPI	SPM1
L201	Coil, variable .8 - 2.2 mH	GPI	LS25-6
L202	Coil, variable 12 - 30 uH	GPI	LS25-7
L203	Coil, variable 30 - 100 uH	GPI	LS25-9
R201	Resistor, composition 47K 10% ½W		
R202	Resistor, composition 47K 10% ½W		
R203	Resistor, composition 330 ohms 10% ½W		
R204	Resistor, composition 2.2K 10% ½W		
R205	Resistor, composition 22K 10% ½W		
R206	Resistor, composition 4.7K 10% ½W		
R207	Resistor, composition 2.2K 10% ½W		
R208	Resistor, composition 47K 10% ½W		
R209	Resistor, composition 1.5K 10% ½W		
R210	Resistor, composition 100 ohms 10% ½W		
R211	Resistor, composition 680 ohms 10% ½W		
R212	Resistor, composition 100K 10% ½W		
R213	Resistor, composition 4.7K 10% ½W		
R214	Resistor, composition 2.2K 10% ½W		
R215	Resistor, composition 220K 10% ½W		
R216	Resistor, composition 220 ohms 10% ½W		
R217	Resistor, composition 15K 10% ½W		
R218	Resistor, composition 2.2K 10% ½W		
R219	Resistor, composition 220K 10% ½W		
R220	Resistor, composition 4.7K 10% ½W		
R221	Resistor, composition 220 ohms 10% ½W		
R222	Resistor, composition 22K 10% ½W		
R223	Resistor, composition 2.2K 10% ½ W		
R224	Resistor, composition 4.7K 10% ½W		
R225	Resistor, composition 220K 10% ½W		
R226	Resistor, var ww 3K	Mel Rain	104
R227	Resistor, composition 47K 10% ½W		
S201	Switch	GPI	SW11
T201	Transformer, variable 12 - 30 uH	GPI	LS25-8
T202	Transformer, variable 30 - 100 uH	GPI	LS25-10
TP201 thru TP203	Test point (3 req'd.)	Sealectro	SKT5BC
V201	Electron tube		6AS6
V202	Electron tube		6AK5
V203	Electron tube		6AS6
V204	Electron tube		6AK5
XV201 thru XV204	Socket, tube (4 req'd.)	Cinch	53C24761

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SYM-BOL	DESCRIPTION	MANUFACTURER	PART NO.
C301	Capacitor, ceramic 13 pF	Erie	831N330-13K
C302	Capacitor, mica 4300 pF	Elmenco	DM20E432J
C303	Capacitor, mica 110 pF	Elmenco	DM15E111J
C304	Capacitor, ceramic .1 uF	Erie	827Z5V104P
C305	Capacitor, mica 110 pF	Elmenco	DM15E111J
C306 thru C315	Capacitor, var mica 1.5 - 20 pF (5 trimmers per assy. 2 req'd.)	GPI	CM3
C316	Capacitor, ceramic .1 uF	Erie	827Z5V104P
C317	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C318	Capacitor, mica 110 pF	Elmenco	DM15E111J
C319	Capacitor, ceramic .1 uF	Erie	827Z5V104P
C320 thru C328	Capacitor, var mica 1.5 - 20 pF (5 trimmers per assy. 2 req'd.)	GPI	CM3
C329	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C330	Capacitor, plastic .015 uF	Goodall	663UW-015UF200V
C331	Capacitor, ceramic .1 uF	Erie	827Z5V104P
C332	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C333	Capacitor, mica 110 pF	Elmenco	DM15E111J
C334	Capacitor, ceramic .1 uF	Erie	827Z5V104P
C335 thru C343	Capacitor, var mica 1.5 - 20 pF (5 trimmers per assy. 2 req'd.)	GPI	CM3
C344	Capacitor, ceramic 27 pF	Erie	831N750-27K
C345	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C346	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C347	Capacitor, mica 110 pF	Elmenco	DM15E111J
C348	Capacitor, ceramic .1 uF	Erie	827Z5V104P
C349 thru C357	Capacitor, var mica 1.5 - 20 pF (5 trimmers per assy. 2 req'd.)	GPI	CM3
C358	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C359	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C360	Capacitor, var mica 1.5 - 20 pF (part of C328)		
C361	Capacitor, var mica 1.5 - 20 pF (part of C357)		
C362	Capacitor, var mica 1.5 - 20 pF (part of C343)		
C363	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C364	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C365	Capacitor, mica 110 pF	Elmenco	DM15E111J
CR301	Diode	Transitron	IN273
CR302	Diode	Hughes	IN95
J301 thru J306	Connector, receptacle (6 req'd.)	GPI	SPM1
J307	Connector, receptacle	Amphenol	126-219
L301	Coil, variable 10 - 24 mH	GPI	LS25-17
L302	Coil, variable .3 - 1.1 mH	GPI	LS25-11
L303	Coil, variable .41 - 1.25 mH	GPI	LS25-13

SYM-BOL	DESCRIPTION	MANUFACTURER	PART NO.
R301	Resistor, composition 680K 10% ½W		
R302	Resistor, composition 10K 10% ½W		
R303	Resistor, composition 2.2K 10% ½W		
R304	Resistor, composition 330 ohms 10% ½W		
R305	Resistor, composition 22K 10% ½W		
R306	Resistor, composition 3.3K 10% ½W		
R307	Resistor, composition 220K 10% ½W		
R308	Resistor, composition 100 ohms 10% ½W		
R309	Resistor, composition 47K 10% ½W		
R310	Resistor, composition 2.2K 10% ½W		
R311	Resistor, composition 22K 10% ½W		
R312	Resistor, composition 1K 10% ½W		
R313	Resistor, composition 100K 10% ½W		
R314	Resistor, composition 4.7K 10% ½W		
R315	Resistor, composition 1.5K 10% ½W		
R316	Resistor, composition 6.8K 10% ½W		
R317	Resistor, composition 220 ohms 10% ½W		
R318	Resistor, composition 15K 10% ½W		
R319	Resistor, composition 2.2K 10% ½W		
R320	Resistor, composition 220K 10% ½W		
R321	Resistor, composition 4.7K 10% ½W		
R322	Resistor, composition 2.2K 10% ½W		
R323	Resistor, composition 22K 10% ½W		
R324	Resistor, composition 4.7K 10% ½W		
R325	Resistor, composition 100K 10% ½W		
R326	Resistor, composition 220K 10% ½W		
R327	Resistor, variable ww 3K	Mel Rain	104
R328	Resistor, composition 47K 10% ½W		
S301	Switch	GPI	SW31
T301	Transformer, variable .3 - 1.1 mH	GPI	LS25-12
T302	Transformer, variable .41 - 1.25 mH	GPI	LS25-14
TP301 thru TP303	Test point (3 req'd.)	Sealectro	SKT5BC
V301	Electron tube		6AS6
V302	Electron tube		6AK5
V303	Electron tube		6AS6
V304	Electron tube		6AK5
XV301 thru XV304	Socket, tube (4 req'd.)	Cinch	53C24761
	L.F.O.		
C401	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C402	Capacitor, mica 110 pF	Elmenco	DM15E111J
C403	Capacitor, ceramic .1 uF	Erie	827Z5V104P
C404	Capacitor, ceramic .1 uF	Erie	827Z5V104P

SYM-BOL	DESCRIPTION	MANUFACTURER	PART NO.
C405	Capacitor, ceramic .1 uF	Erie	827Z5V104P
C406	Capacitor, mica 1300 pF	Elmenco	DM19E132J
C407	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C408	Capacitor, ceramic .1 uF	Erie	827Z5V104P
C409	Capacitor, ceramic .1 uF	Erie	827Z5V104P
C410	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C411	Capacitor, mica 2000 pF	Elmenco	DM19E202J
C412	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C413	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C414	Capacitor, mica 220 pF	Elmenco	DM15E221J
C415	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C416	Capacitor, paper .5 uF	Hopkins Eng.	P52DS
C417	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C418	Capacitor, ceramic .1 uF	Erie	827Z5V104P
C419	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C420	Capacitor, ceramic N750-680 pF	Centralab	TCN680
C421	Capacitor, var quartz .6 - 14 pF	JFD Electronics	VC11G
C422	Capacitor, var ceramic NPO2X5 - 25 pF	GPI	CA7
C423	Capacitor, var air 33 - 759 pF	GPI	CA4
C424	Capacitor, mica 330 pF	Elmenco	CM15E331F
C425	Capacitor, mica 2000 pF	Elmenco	DM19E202J
C426	Capacitor, ceramic .1 uF	Erie	827Z5V104P
C427	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C428	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C429	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C430	Capacitor, mica 110 pF	Elmenco	DM15E111J
C431	Capacitor, mica 82 pF	Elmenco	DM15E820J
C432	Capacitor, mica 180 pF	Elmenco	DM15E181J
C433	Capacitor, ceramic 10 pF	Erie	831N330 - 10F
C434	Capacitor, var ceramic N500 - 7 - 45 pF	Erie	503N5007-45
CR401	Diode	Hughes	IN95
CR402	Diode	Hughes	IN95
CR403	Diode	Hughes	IN95
DS401	Lamp, incandescent	General Elec.	328
J401	Connector, receptacle	GPI	SPM1
J402	Connector, receptacle	GPI	SPM1
J403	Connector, receptacle	Amphenol	126-219
J404	Connector, receptacle		UG657U
J405	Connector, receptacle	GPI	SPM1
J406	Connector, receptacle	GPI	SPM1
L401	Coil, variable 4.5 - 12.5 mH	GPI	LS25-15
L402	Coil, variable 4.5 - 12.5 mH	GPI	LS25-15
L403	Coil, variable 126 - 250 uH	Miller	4410
L404	Coil, variable 4.5 - 12.5 mH	GPI	LS25-15

SYM-BOL	DESCRIPTION	MANUFACTURER	PART NO.
R401	Resistor, composition 15K 10% ½W		
R402	Resistor, composition 1 mego 10% ½W		
R403	Resistor, composition 330 ohms 10% ½W		
R404	Resistor, composition 47K 10% ½W		
R405	Resistor, composition 4.7K 10% ½W		
R406	Resistor, composition 1 mego 10% ½W		
R407	Resistor, composition 220 ohms 10% ½W		
R408	Resistor, composition 22K 10% ½W		
R409	Resistor, composition 2.2K 10% ½W		
R410	Resistor, composition 47K 10% ½W		
R411	Resistor, composition 47K 10% ½W		
R412	Resistor, composition 150K 10% ½W		
R413	Resistor, composition 150K 10% ½W		
R414	Resistor, composition 47K 10% ½W		
R415	Resistor, composition 47K 10% ½W		
R416	Resistor, composition 2.2K 10% ½W		
R417	Resistor, composition 47K 10% ½W		
R418	Resistor, composition 4.7K 10% ½W		
R419	Resistor, composition 1.5 10% ½W		
R420	Resistor, composition 22K 10% 1W		
R421	Resistor, composition 2.2K 10% ½W		
R422	Resistor, composition 1 mego 10% ½W		
R423	Resistor, composition 22K 10% ½W		
R424	Resistor, composition 470 ohms 10% ½W		
R425	Resistor, composition 22K 10% ½W		
R426	Resistor, composition 10K 10% ½W		
R427	Resistor, composition 10K 10% ½W		
R428	Resistor, composition 220K 10% ½W		
R429	Resistor, composition 22K 10% ½W		
R430	Resistor, composition 470 ohms 10% ½W		
R431	Resistor, composition 22K 10% ½W		
R432	Resistor, composition 470 ohms 10% ½W		
R433	Resistor, composition 220K 10% ½W		
R434	Resistor, composition 47 ohms 10% ½W		
R435	Resistor, composition 10 ohms 10% ½W		
R436	Resistor, composition 10K 10% ½W		
S401	Switch	GPI	SW28
TP401 thru TP402	Test point (4 req'd.)	Sealectro	SKT5BC
V401	Electron tube		6AS6
V402	Electron tube		6AK5
V403	Electron tube		6AS6
V404	Electron tube		12AT7
V405	Electron tube		12AT7
XDS401	Indicator light	Dialco	TT61B7

SYM-BOL	DESCRIPTION	MANUFACTURER	PART NO.
XV401 thru XV403	Socket, tube (3 req'd.)	Cinch	53C24761
XV404	Socket, tube	Cinch	44F24760
XV405	Socket, tube	Cinch	44F24760

CRYSTAL OSCILLATOR & AUDIO AMPLIFIER CHASSIS

C501	Capacitor, ceramic .001 uF	Erie	861Z5U102Z
C502	Capacitor, ceramic .001 uF	Erie	861Z5U102Z
C503	Capacitor, mica 110 pF	Elmenco	DM15E111J
C504	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C505	Capacitor, ceramic .1 uF	Erie	827Z5V104P
C506	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C508	Capacitor, electrolytic 5 uF 150V	Aerovox	E26G50
C509	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C510	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C511	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C513	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C514	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C515	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C516	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C517	Capacitor, mica 110 pF	Elmenco	DM15E111J
C518	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C519	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
C520	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C521	Capacitor, mica 620 pF nominal	Elmenco	DM15E621J
C522	Capacitor, var ceramic 2x8 - 50 pF	GPI	CA5
C523	Capacitor, var ceramic 2x8 - 50 pF	GPI	CA5
C524	Capacitor, mica 620 pF nominal	Elmenco	DM15E621J
C525	Capacitor, ceramic .1 uF	Erie	827Z5V104P
C526	Capacitor, electrolytic 5 uF 150V	Aerovox	E26G50
C527 thru C530	Capacitor, mica 33 pF, (4 req'd.)	Elmenco	DM15E330J
C531	Capacitor, mica 33 pF	Elmenco	DM15E330J
C540	Capacitor, ceramic .005 uF	Erie	801Z5U502Z
CR501	Diode	General Elec.	SD150
CR502	Diode	Transitron	IN273
CR503	Diode	Hughes	IN95
CR505	Diode	Hughes	IN95
J501 thru J504	Connector, receptacle (4 req'd.)	GPI	SPM1
J505	Jack, phone	Switchcraft	11
J506	Connector, receptacle	GPI	SPM1
J507	Connector, receptacle		UG657U
J508	Connector, receptacle	Winchester	M12PLS12N

SYM-BOL	DESCRIPTION	MANUFACTURER	PART NO.
R501	Resistor, composition 10K 10% ½W		
R502	Resistor, composition 47 ohms 10% ½W		
R503	Resistor, composition 10K 10% ½W		
R504	Resistor, composition 100K 10% ½W		
R505	Resistor, composition 100K 10% ½W		
R506	Resistor, composition 10 mego 10% ½W		
R507	Resistor, composition 220K 10% ½W		
R508	Resistor, composition 470K 10% ½W		
R509	Resistor, composition 10 mego 10% ½W		
R510	Resistor, composition 150K 10% ½W		
R511	Resistor, composition 2.2K 10% ½W		
R512	Resistor, composition 270 ohms 10% ½W		
R513	Resistor, variable composition 1 mego	GPI	RV11
R514	Resistor, composition 82K 10% ½W		
R515	Resistor, composition 47K 10% ½W		
R516	Resistor, composition 15K 10% ½W		
R517	Resistor, variable ww 1K	Mel Rain	106
R518	Resistor, composition 47 ohms 10% ½W		
R519	Resistor, composition 100K 10% ½W		
R520	Resistor, composition 220K 10% ½W		
R521	Resistor, composition 22K 10% ½W		
R522	Resistor, composition 10K 10% ½W		
R523	Resistor, composition 10K 10% ½W		
R525	Resistor, composition 150K 10% ½W		
R526	Resistor, composition 1 mego 10% ½W		
R527	Resistor, composition 100K 10% ½W		
R528	Resistor, composition 2.2K 10% ½W		
R529	Resistor, composition 1 mego 10% ½W		
R530	Resistor, composition 39K 10% ½W		
R531	Resistor, composition 47K 10% ½W		
R532	Resistor, composition 2.2K 10% ½W		
R533	Resistor, composition 47K 10% ½W		
R534	Resistor, composition 1.5K 10% ½W		
R535	Resistor, variable ww 1K	Mel Rain	106
R536	Resistor, composition 100K 10% ½W		
R537	Resistor, composition 220K 10% ½W		
R538	Resistor, composition 22K 10% ½W		
R539	Resistor, composition 4.7K 10% ½W		
R540	Resistor, variable composition 150K	Bourns	215L1-154
S501	Switch	GPI	SW14
T501	Transformer	GPI	TP3
T502	Transformer, variable .3 - 1 mH	GPI	LS25-16
V501	Electron tube		12AX7
V502	Electron tube		12AT7

SYM-BOL	DESCRIPTION	MANUFACTURER	PART NO.
V503	Electron tube		6AK5
V504	Electron tube		6AK5
V505	Electron tube		12AT7
XV501	Socket, tube	Cinch	44F24760
XV502	Socket, tube	Cinch	44F24760
XV503 thru XV505	Socket, tube (3 req'd.)	Cinch	53C24761
XY501	Socket, tube	Cinch	51B16759
Y501	Crystal Assembly 1 MC	GPI	YC3
	POWER SUPPLY		
C601	Capacitor, electrolytic 80, 20 uF 400V 10 uF 350V	Sprague	TVL3689
C602	Capacitor, ceramic .01 uF	Erie	851Z5U103Z
C603	Capacitor, ceramic .1 uF	Erie	827Z5V104P
CR601 thru CR604	Diode (4 req'd.)	Sarkes Tarzian	M150
F601	Fuse (for 115V operation) 1 Amp	Bussmann	MDL1
F601	Fuse (for 230V operation) .5 Amp	Bussmann	MDL1-2
I601	Lamp, incandescent	Tung-Sol	1813
I602	Lamp, neon	General Elec.	NE51H
I603	Lamp, neon	General Elec.	NE51H
J601	Connector, receptacle	Tower	H10610A
J602	Connector, receptacle	Amphenol	126-221
R601	Resistor, composition 47K 10% ½W		
R602	Resistor, wire wound 4K 15W	Truohm	MOR15-4000
R603	Resistor, composition 470K 10% ½W		
R604	Resistor, composition 1K 10% ½W		
R605	Resistor, composition 1K 10% ½W		
R606	Resistor, composition 10 ohms 10% ½W		
R607	Resistor, composition 10 ohms 10% ½W		
R608	Resistor, wire wound 7.5K 5W	Ward Leonard	5X7500
R609	Resistor, composition 390K 10% ½W		
R610	Resistor, composition 330K 10% ½W		
R611	Resistor, composition 220K 10% ½W		
R612	Resistor, composition 47K 10% ½W		
S601	Switch, toggle DPST	Arrow Hart	20902JH
S602	Switch, toggle DPST	Arrow Hart	20902JH
T601	Transformer, power	GPI	TP4
TB601	Terminal board assy.	Cinch	1774-5101P24
TP601	Test, point	Sealectro	SKT5BC
V601	Electron tube		6BX7
V602	Electron tube		6AK5
V603	Electron tube		OC2
XCR601, 2	Fuseholder	Bussmann	3795

SYM-BOL	DESCRIPTION	MANUFACTURER	PART NO.
XCR603, 4	Fuseholder	Bussmann	3795
XF601	Fuseholder	Littelfuse	342004
XI601 thru XI603	Indicator light (3 req'd.)	Marco	VM312-6
XV601	Socket, tube	Cinch	51B16758
XV602	Socket, tube	Cinch	53C24761
XV603	Socket, tube	Cinch	53C24761

FRONT PANEL

J701	Connector, receptacle		UG492AU
J702	Connector, receptacle		UG657U
J703	Connector, receptacle		UG657U
M701	Meter, tune max.	GPI	ME5MA6
M702	Meter, tune max.	GPI	ME5MA6
M703	Meter, tune max.	GPI	ME5MA6
M704	Meter, zero center	GPI	ME6
M705	Meter, zero center	GPI	ME6
S701	Switch, toggle	Carling	11273
W701	Cable Assembly	GPI	DI153
W702	Power cable	Belden	KH3385
WP702	Adapter plug	Cornish	228
	Knob, plain (1 req'd	Johnson	116-220-2
	Knob, dot (2 req'd)	Johnson	116-224-2
	Knob, crank (2 req'd)	Johnson	116-266-2
	Knob, bar (2 req'd)	GPI	OP1
	Knob, small (2 req'd)	Harry Davies	1450W

SUBSTITUTIONS: When expedient, equivalent components may be substituted at the factory. Performance will not be impaired. When making replacements, either parts in this list or the substituted equivalent may be used.